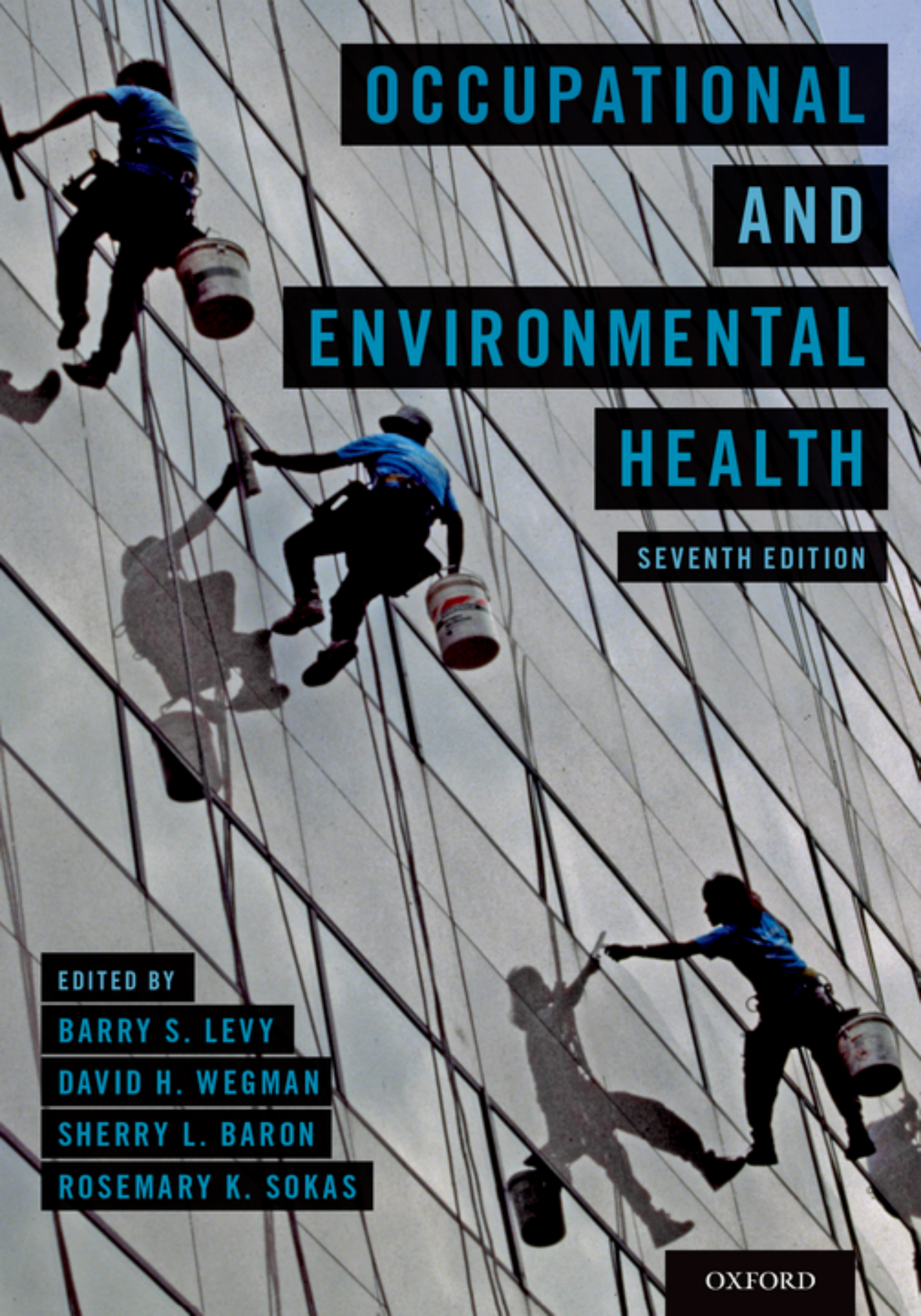


A low-angle photograph of three workers in blue shirts and dark pants, silhouetted against a bright sky, as they clean or maintain a glass skyscraper. They are suspended by ropes and carry buckets. Their shadows are cast onto the glass surface below them.

OCCUPATIONAL AND ENVIRONMENTAL HEALTH

SEVENTH EDITION

EDITED BY

BARRY S. LEVY

DAVID H. WEGMAN

SHERRY L. BARON

ROSEMARY K. SOKAS

OXFORD

Occupational and Environmental Health

Occupational and Environmental Health

Recognizing and Preventing
Disease and Injury

Seventh Edition

Edited by

Barry S. Levy

David H. Wegman

Sherry L. Baron

Rosemary K. Sokas

with the assistance of

Heather L. McStowe

OXFORD
UNIVERSITY PRESS

OXFORD
UNIVERSITY PRESS

Oxford University Press is a department of the University of Oxford. It furthers the University's objective of excellence in research, scholarship, and education by publishing worldwide. Oxford is a registered trade mark of Oxford University Press in the UK and certain other countries.

Published in the United States of America by Oxford University Press
198 Madison Avenue, New York, NY 10016, United States of America.

© Oxford University Press 2018

Fourth edition published by 2000
Fifth edition published by 2006
Sixth edition published by 2011
Seventh edition published by 2018

All rights reserved. No part of this publication may be reproduced, stored in a retrieval system, or transmitted, in any form or by any means, without the prior permission in writing of Oxford University Press, or as expressly permitted by law, by license, or under terms agreed with the appropriate reproduction rights organization. Inquiries concerning reproduction outside the scope of the above should be sent to the Rights Department, Oxford University Press, at the address above.

You must not circulate this work in any other form
and you must impose this same condition on any acquirer.

Library of Congress Cataloging-in-Publication Data

Names: Levy, Barry S., editor. | Wegman, David H., editor. | Baron, Sherry, L. editor. | Sokas, Rosemary K., editor.

Title: Occupational and environmental health : recognizing and preventing disease and injury / edited by Barry S. Levy, David H. Wegman, Sherry L. Baron, Rosemary K. Sokas, with the assistance of Heather L. McStowe.

Other titles: Occupational health (Levy) Description: Seventh edition. | Oxford ; New York : Oxford University Press, [2018] | Includes bibliographical references and index.

Identifiers: LCCN 2017012926 (print) | LCCN 2017014701 (ebook) |

ISBN 9780190662684 (updf) | ISBN 9780190662691 (epub) | ISBN 9780190662677 (pbk. : alk. paper)

Subjects: | MESH: Occupational Diseases—prevention & control | Occupational Exposure—prevention & control | Environmental Exposure—prevention & control | Occupational Health | Environmental Health

Classification: LCC RC963 (ebook) | LCC RC963 (print) | NLM WA 440 |

DDC 616.9/803—dc23

LC record available at <https://lcn.loc.gov/2017012926>

9 8 7 6 5 4 3 2 1

Printed by Sheridan Books, Inc., United States of America

Contents

Preface [ix](#)

Acknowledgments [xi](#)

About the Editors [xiii](#)

Contributors [xv](#)

Disclaimer [xxiii](#)

Frequently Used Abbreviations [xxv](#)

SECTION I. INTRODUCTION

1. Occupational and Environmental Health Challenges and Opportunities [3](#)
Barry S. Levy, David H. Wegman, Sherry L. Baron, and Rosemary K. Sokas
2. Occupational and Environmental Health Equity and Social Justice [23](#)
Cora Roelofs, Sherry L. Baron, Sacoby Wilson, and Aaron Aber
3. The Roles of Government in Protecting and Promoting Occupational and Environmental Health [41](#)
Gregory R. Wagner and Emily A. Spieler

SECTION II. RECOGNITION, ASSESSMENT, AND PREVENTION

4. Recognizing and Preventing Occupational and Environmental Disease and Injury [59](#)
Rosemary K. Sokas, Barry S. Levy, David H. Wegman, and Sherry L. Baron
5. Epidemiology [79](#)
Sadie Costello, Jennifer M. Cavallari, David H. Wegman, Marie S. O'Neill, and Ellen A. Eisen

6. Occupational and Environmental Health Surveillance 101
Letitia Davis and Kerry Souza
7. Toxicology 115
Robert Laumbach and Michael Gochfeld
8. Occupational and Environmental Hygiene 145
John D. Meeker
9. Occupational Ergonomics: Promoting Safety and Health through Work Design 177
W. Monroe Keyserling
10. Clinical Occupational and Environmental Health Practice 193
Bonnie Rogers

SECTION III. HAZARDOUS EXPOSURES

11. Chemical Hazards 207
Michael Gochfeld and Robert Laumbach
- 12A. Noise Exposure and Hearing Disorders 243
David C. Byrne and Thais C. Morata
- 12B. Vibration 259
Peter W. Johnson and Martin G. Cherniack
- 12C. Extremes of Temperature 271
Ann M. Krake
- 12D. Ionizing and Non-ionizing Radiation 289
John Cardarelli II
13. Biological Hazards 309
Mark Russi
14. Occupational Stress 325
Paul A. Landsbergis, Marnie Dobson, Anthony D. LaMontagne, BongKyoo Choi, Peter Schnall, and Dean B. Baker
15. Air Pollution 345
Horacio Riojas-Rodríguez, Isabelle Romieu, and Mauricio Hernández-Ávila
16. Water Contamination 365
Jeffery A. Foran and Amaryl Griggs
17. Food Safety 381
Craig W. Hedberg
18. Hazardous Waste 393
Ken Silver, Gary A. Davis, and Denny Dobbin

SECTION IV. ADVERSE HEALTH EFFECTS

19. Injuries and Occupational Safety 411
Dawn N. Castillo, Timothy J. Pizatella, and Nancy A. Stout
20. Musculoskeletal Disorders 433
Carisa Harris-Adamson, Stephen S. Bao, and Bradley Evanoff

21. Cancer 461
Elizabeth Ward
22. Respiratory Disorders 499
Crystal M. North and David C. Christiani
23. Neurological Disorders 531
Margit L. Bleecker
24. Reproductive and Developmental Disorders 543
Linda M. Frazier and Deborah Barkin Fromer
25. Skin Disorders 557
Loren C. Tapp and Boris D. Lushniak
26. Cardiovascular Disorders 573
Kenneth D. Rosenman
27. Liver Disorders 587
Barry S. Levy
28. Kidney Disorders 593
Virginia M. Weaver, Bernard G. Jaar, and Jeffrey J. Fadrowski

SECTION V. AN INTEGRATED APPROACH TO PREVENTION

29. Climate Change 605
Barry S. Levy and Jonathan A. Patz
30. Children's Environmental Health 619
Philip J. Landrigan
31. Protecting Disaster Rescue and Recovery Workers 633
*Dori B. Reissman, Maryann M. D'Alessandro, Lisa Delaney,
and John Piacentino*
- 32A. Hazards for Agricultural Workers 653
Amy K. Liebman and John May
- 32B. Hazards for Construction Workers 663
Gavin H. West and Laura S. Welch
- 32C. Hazards for Healthcare Workers 673
Jane A. Lipscomb
33. Conducting Worksite Investigations 681
Bruce P. Bernard
34. Addressing the Built Environment and Health 695
Richard J. Jackson
35. A Global Perspective on Occupational Health and Safety 713
Jorma H. Rantanen

Appendix: Illustrative Organizations 733

Index 737

Preface

Occupational and environmental health problems profoundly affect health and safety at the individual, family, community, national, and global level. All of us, as health and safety professionals, have important roles to play in recognizing and preventing these problems. We believe that a solid understanding of the core concepts of occupational and environmental health informs and empowers health and safety professionals to play these roles effectively.

The seventh edition of this textbook is intended to support health and safety professionals as well as students in the health professions in recognizing and preventing occupational and environmental diseases and injuries in individuals and populations. It is also intended to provide them with an understanding of the contexts in which these diseases and injuries occur. Although our focus is primarily on occupational and environmental health in the United States, we believe that this book will be useful to practitioners and students in health and safety professions throughout the world.

Dramatic changes continue to impact both occupational and environmental health, such as recognition of new workplace health hazards, the changing nature of work, global climate change, and the increasingly recognized vulnerabilities of children to hazardous exposures. In addition, dramatic changes continue to impact how we obtain, analyze, communicate, and use information for practice, prevention, research, advocacy, and policy development.

Along with the rapidly changing landscape, important relationships between occupational health and environmental health are increasingly recognized. For example, environmental health problems frequently originate in the workplace, and work-related hazards, environmental degradation, poverty, and social injustice are often interrelated. This textbook aims to reflect these developments and to enable readers to prepare themselves to recognize and prevent occupational and environmental diseases and injuries in a changing world.

We have extensively updated chapters from the sixth edition, continuing to emphasize aspects of both occupational and environmental health. In addition, we have added new chapters on climate change, children's environmental health, liver

disorders, kidney disorders, and a global perspective on occupational health and safety.

All of the chapters in this book address ways in which health and safety professionals can recognize and prevent occupational and environmental health problems. Effectively addressing these problems calls for health and safety professionals to collaborate with people throughout society—business and labor leaders, government officials and representatives of nongovernmental organizations, educators and journalists, and, most importantly, workers and community members at risk of developing these problems. By engaging with others in partnerships and coalitions, we believe that readers will be able to translate the information in this book into policy and action to prevent disease, injury, and premature death and to promote health, safety, and quality of life.

The Editors
July 2017

Acknowledgments

We greatly appreciate the assistance and support of many people in the development of the seventh edition of *Occupational and Environmental Health*. We thank the many chapter authors, whose work is appropriately credited within the text. In addition, there have been many other people working behind the scenes, whom we deeply appreciate.

We acknowledge Heather McStowe for her excellent work in preparing the manuscript and communicating with the many contributors to the book.

We are grateful for the outstanding work and support of Chad Zimmerman and Chloe Layman at Oxford University Press and Rajeswari Balasubramanian at Newgen Knowledge Works.

The illustrative materials throughout the book reinforce key points and provide additional insights. We call special attention to the work of Earl Dotter, who provided many outstanding photographs to illustrate a wide range of occupational and environmental health issues, and Nick Thorkelson, who contributed creative drawings that provide fresh perspectives. We are also grateful for the photographic contributions of Aaron Sussell, David Parker, Marvin Lewiton, Nick Kaufman, and Frank Wenzel.

We express our deep appreciation to our families for their ongoing support.

Finally, we thank the many students, colleagues, workers, community members, and occupational and environmental health educators, researchers, governmental officials, advocates, and others, who, over the years, have broadened—and continue to broaden—our understanding of occupational and environmental health.

The Editors

About the Editors

The following section briefly describes the editors, who also edited earlier editions of this book.

Barry S. Levy, MD, MPH, is an occupational and environmental health physician and epidemiologist who is an Adjunct Professor of Public Health at Tufts University School of Medicine and a consultant in occupational and environmental health. He has co-edited 18 other books on occupational and environmental health, climate change, war and terrorism, and social injustice and authored more than 200 journal articles and book chapters. He previously worked as an epidemiologist at the Centers for Disease Control and Prevention, as a professor and director of the Occupational Health Program at the University of Massachusetts Medical School, and as a director of international health programs and projects. He has served as president of the American Public Health Association.

David H. Wegman, MD, MSc, is a physician epidemiologist engaged for 45 years in public health research and practice on the health and safety of working people. He is Professor Emeritus, Department of Work Environment, University of Massachusetts Lowell, and Adjunct Professor, Harvard T.H. Chan School of Public Health. He previously served on the faculty of the UCLA School of Public Health. Dr. Wegman currently directs chronic kidney disease research in Central America. He serves as Vice-President of the Alpha Foundation for Improvement of Mine Safety and Health. In addition, he consults to the Occupational Health Surveillance Program of the Massachusetts Department of Public Health and serves on committees and two boards of the National Academies of Sciences, Engineering, and Medicine.

Sherry L. Baron, MD, MPH, is a Professor of Occupational and Environmental Health at the Barry Commoner Center for Health and the Environment and the Department of Urban Studies at Queens College of the City University of New York (CUNY). She is also an affiliated faculty member of the CUNY Graduate School of Public Health and Health Policy. She previously worked for 25 years as a medical

epidemiologist at the National Institute for Occupational Safety and Health (NIOSH) and served as the NIOSH coordinator for occupational health disparities. Her current interests focus on performing research on the intersection of work and health for low-wage and immigrant workers and on developing community-based programs to improve health.

Rosemary K. Sokas, MD, MOH, is Professor and Immediate Past Chair, Department of Human Science of the School of Nursing and Health Studies at Georgetown University. She has previously served on the faculty of the University of Pennsylvania and the George Washington University schools of medicine and the University of Illinois at Chicago School of Public Health, where she directed the Division of Environmental and Occupational Health Sciences. She has served as Associate Director for Science at NIOSH and directed the Office of Occupational Medicine of the Occupational Safety and Health Administration. Her research interests include occupational health disparities, evaluation of intervention effectiveness, and participatory action research among high-risk, low-wage workers.

Contributors

Aaron Aber, BS

University of Maryland
aaronjaber@gmail.com

Dean B. Baker, MD, MPH

Professor of Medicine, Epidemiology,
and Public Health
Center for Occupational and
Environmental Health
University of California, Irvine
Irvine, CA
dbaker@uci.edu

Stephen S. Bao, PhD, CPE, CCPE

Senior Epidemiologist
Washington State Department of Labor
& Industries
Olympia, WA
baos235@lni.wa.gov

Sherry L. Baron, MD, MPH

Professor of Occupational and
Environmental Health
Barry Commoner Center for Health and
the Environment
Department of Urban Studies
Queens College
City University of New York
New York, NY
Sherry.Baron@qc.cuny.edu

Bruce P. Bernard, MD, MPH

Captain, U.S. Public Health Service
Chief Medical Officer
Hazard Evaluations and Technical
Assistance Branch
National Institute for Occupational
Safety and Health
Cincinnati, OH
bpb4@cdc.gov

Margit L. Bleecker, MD, PhD

Director
Center for Occupational and
Environmental Neurology
Baltimore, MD

David C. Byrne, PhD

Research Audiologist
Captain, U.S. Public Health Service
National Institute for Occupational
Safety and Health
Cincinnati, OH
zne2@cdc.gov

John Cardarelli II, PhD, CHP, CIH, PE

Captain, U.S. Public Health Service
Health Physicist
Environmental Protection Agency
CBRN Consequence Management
Advisory Team
Erlanger, KY
Cardarelli.John@epa.gov

Dawn N. Castillo, MPH

Director
Division of Safety Research
National Institute for Occupational
Safety and Health
Morgantown, WV
dnc0@cdc.gov

Jennifer M. Cavallari, ScD, CIH

Assistant Professor, Community
Medicine and Health Care
Department of Community Medicine
University of Connecticut School of
Medicine
Farmington, CT
cavallari@uchc.edu

Martin G. Cherniack, MD, MPH

Professor of Medicine
University of Connecticut School of
Medicine
Farmington, CT
cherniack@uchc.edu

BongKyoo Choi, ScD, MPH

Assistant Professor
Center for Occupational and
Environmental Health
Environmental Health Sciences
Graduate Program
School of Medicine
University of California, Irvine
Irvine, CA
b.choi@uci.edu

David C. Christiani, MD, MPH, MS

Director
Environmental and Occupational
Medicine and Epidemiology Program
Harvard T. H. Chan School of
Public Health
Professor of Medicine
Harvard Medical School
Boston, MA
dchris@hsph.harvard.edu

Sadie Costello, PhD

Assistant Researcher
Environmental Health Sciences Division
School of Public Health
University of California, Berkeley
Berkeley, CA
sadie@berkeley.edu

Maryann M. D'Alessandro, PhD

Director, National Personal Protective
Technology Laboratory
National Institute for Occupational
Safety and Health
Pittsburgh, PA
bpj5@cdc.gov

Juan C. Dapena, MD

Undersea Medical Officer
U.S. Navy
Silverdale, WA
juan.dapena@navy.mil

Gary A. Davis

Davis & Whitlock, PC
Asheville, NC
gadavis@enviroattorney.com

Letitia Davis, ScD

Former Director
Occupational Health Surveillance
Program
Massachusetts Department of
Public Health
Cambridge, MA
Lkdavis49@gmail.com

Lisa Delaney, MS, CIH

Associate Director for Emergency
Preparedness and Response
National Institute for Occupational
Safety and Health
Atlanta, GA
lkd2@cdc.gov

Denny Dobbin, MSc, CIH

Chapel Hill, NC
rddobbin@att.net

Marnie Dobson, PhD

Assistant Adjunct Professor
Center for Occupational and
Environmental Health
School of Medicine
University of California, Irvine
Irvine, CA
mdobson@uci.edu

Ellen A. Eisen, ScD

Professor and Head
Environmental Health Sciences Division
School of Public Health
University of California, Berkeley
Berkeley, CA
eeisen@berkeley.edu

Bradley Evanoff, MD, MPH

Richard and Elizabeth Henby Sutter
Professor of Occupational and
Environmental Medicine
Director
Division of General Medical Sciences
School of Medicine
Washington University
St. Louis, MO
bevanoff@wustl.edu

Jeffrey J. Fadrowski, MD, MHS

Associate Professor of Pediatrics
Associate Pediatric Residency Program
Director
Division of Pediatric Nephrology
Johns Hopkins University School of
Medicine
Baltimore, MD
jfadrow1@jhmi.edu

Jeffery A. Foran, PhD

Professor and Chair
Department of Environmental Studies
California State University, Sacramento
Sacramento, CA
jeffery.foran@csus.edu

Linda M. Frazier, MD, MPH

Philadelphia, PA
Lfrazier151@comcast.net

**Deborah Barkin Fromer, MT
(ASCP), MPH**

New York, NY
db.fromer@gmail.com

Michael Gochfeld, MD, PhD

Professor Emeritus
Clinical Research and Occupational
Medicine
Environmental and Occupational
Health Sciences Institute
Rutgers University
Piscataway, NJ
mg930@eohsi.rutgers.edu

Amaryl Griggs

Undergraduate in Environmental
Studies
California State University, Sacramento
Sacramento, CA
amarylgriggs@csus.edu

Carisa Harris-Adamson, PhD, CPE

Assistant Professor
Department of Medicine
University of California, San Francisco
Director
UCSF/UCB Ergonomics Research &
Graduate Training Program
Richmond, CA
Carisa.Harris-Adamson@ucsf.edu

Craig W. Hedberg, PhD

Division of Environmental Health
Sciences
School of Public Health
University of Minnesota
Minneapolis, MN
hedbe005@umn.edu

**Mauricio Hernández-Ávila, MD,
MPH, PhD**

Dean
National Institute of Public Health
of Mexico
Cuernavaca, Morelos, Mexico
mhernan@insp.mx

Bernard G. Jaar, MD, MPH

Assistant Professor
Division of Nephrology
Department of Medicine
Johns Hopkins School of Medicine
Welch Center for Prevention,
Epidemiology and Clinical Research
Johns Hopkins Medical Institutions
Baltimore, MD
bjaar@jhmi.edu

Richard J. Jackson, MD, MPH

Berkeley, CA
dickjackson@ucla.edu

Peter W. Johnson, PhD

Professor
Department of Environmental and
Occupational Health Sciences
University of Washington
Seattle, WA
petej@uw.edu

W. Monroe Keyserling, PhD

Professor
Departments of Industrial and
Operations Engineering and
Environmental Health Science
University of Michigan
Ann Arbor, MI
wmkeyser@umich.edu

Ann M. Krake, MS, REHS, CSP

Captain, U.S. Public Health Service
Chief, Safety and Occupational Health
U.S. Army Corps of Engineers—
Northwestern Division
Portland, OR
Ann.M.Krake@usace.army.mil

**Anthony D. LaMontagne, ScD,
MA, MEd**

Professor of Work, Health & Wellbeing
Director, Centre for Population Health
Research
School of Health & Social Development
Deakin University
Melbourne, Australia
tony.lamontagne@deakin.edu.au

Philip J. Landrigan, MD, MSc

Dean for Global Health
Professor of Pediatrics and
Environmental Medicine
Icahn School of Medicine at Mount Sinai
New York, NY
philip.landrigan@mssm.edu

Paul A. Landsbergis, PhD, EdD, MPH

Associate Professor
Department of Environmental and
Occupational Health Sciences
School of Public Health
SUNY Downstate Medical Center
Brooklyn, NY
paul.landsbergis@downstate.edu

Robert Laumbach, MD, MPH, CIH

Associate Professor
Department of Environmental and
Occupational Health
Rutgers School of Public Health
Environmental and Occupational
Health Sciences Institute
Piscataway, NJ
laumbach@eohsi.rutgers.edu

Barry S. Levy, MD, MPH

Adjunct Professor
Department of Public Health and
Community Medicine
Tufts University School of Medicine
Sherborn, MA
blevy@igc.org

Amy K. Liebman, MPA, MA

Director
Environmental and Occupational Health
Migrant Clinicians Network
Salisbury, MD
aliebman@migrantclinician.org

Jane A. Lipscomb, PhD, RN

Professor
School of Nursing
University of Maryland
Baltimore, MD
lipscomb151@gmail.com

Boris D. Lushniak, MD

Dean and Professor
School of Public Health
University of Maryland
College Park, MD
lushniak@umd.edu

John May, MD

Jane Forbes Clark Professor of Clinical
Medicine and Epidemiology
Columbia University
Research Scientist
Bassett Healthcare Network
Cooperstown, NY
john.may@bassett.org

John D. Meeker, ScD, CIH

Professor
Environmental Health Sciences
Associate Dean for Research
School of Public Health
University of Michigan
Ann Arbor, MI
meekerj@umich.edu

Thais C. Morata, PhD

Coordinator
NORA Manufacturing Sector Council
National Institute for Occupational
Safety and Health
Cincinnati, OH
tcm2@cdc.gov

Crystal M. North, MD

Division of Pulmonary and Critical
Care Medicine
Massachusetts General Hospital
Boston, MA
cnorth@mgh.harvard.edu

Marie S. O'Neill, PhD

Associate Professor
Departments of Environmental Health
Sciences and Epidemiology
School of Public Health
University of Michigan
Ann Arbor, MI
marieo@umich.edu

Jonathan A. Patz, MD, MPH

Director
Global Health Institute
Professor
Nelson Institute
Center for Sustainability and the Global
Environment (SAGE)
Department of Population Health
Sciences
University of Wisconsin – Madison
Madison, WI
patz@wisc.edu

John Piacentino, MD, MPH

Associate Director for Science
National Institute for Occupational
Safety and Health
Washington, DC
gjt4@cdc.gov

Timothy J. Pizatella, MS

Deputy Director
Division of Safety Research
National Institute for Occupational
Safety and Health
Morgantown, WV
tjp2@cdc.gov

Jorma H. Rantanen, MD, PhD

Professor
Director General Emeritus
Finnish Institute of Occupational Health
Visiting Scientist
Department of Public Health/
Occupational Health
University of Helsinki
Helsinki, Finland
jorma.h.rantanen@gmail.com

Dori B. Reissman, MD, MPH

Associate Administrator
World Trade Center Health Program
National Institute for Occupational
Safety and Health
Captain, U.S. Public Health Service
Washington, DC
dvs7@cdc.gov

Horacio Riojas-Rodríguez, MD, PhD

Director of Environmental
Health
National Institute of Public Health
of Mexico
Cuernavaca, Morelos, Mexico
hriojas@insp.mx

Cora Roelofs, ScD

CR Research/Consulting
Boston, MA
cora_roelofs@uml.edu

Bonnie Rogers, DrPH

Director
North Carolina Occupational Safety
and Health Education and Research
Center and Occupational Health
Nursing Program
UNC Gillings School of Public Health
The University of North Carolina at
Chapel Hill
Chapel Hill, NC
Rogersb@email.unc.edu

Isabelle Romieu, MD, MPH, ScD

Montpellier, France
iromieu@gmail.com

Kenneth D. Rosenman, MD

Chief of the Division of Occupational
and Environmental Medicine
Professor of Medicine
Michigan State University
East Lansing, MI
Ken.Rosenman@hc.msu.edu

Mark Russi, MD, MPH

Medical Director
Wellness and Employee
Population Health
Yale-New Haven Health System
Professor
Medicine and Epidemiology
Yale University
New Haven, CT

Peter Schnall, MD, MPH

Clinical Professor of Medicine
Center for Occupational and
Environmental Health
University of California, Irvine
Irvine, CA
pschnall@workhealth.org

Ken Silver, DSc, SM

Associate Professor of
Environmental Health
Department of Environmental Health
East Tennessee State University
Johnson City, TN
silver@mail.etsu.edu

Rosemary K. Sokas, MD, MOH

Professor and Immediate Past Chair
Department of Human Science
School of Nursing and Health Studies
Georgetown University
Washington, DC
sokas@georgetown.edu

Kerry Souza, ScD, MPH

Epidemiologist
Division of Surveillance, Hazard
Evaluations, and Field Studies
National Institute for Occupational
Safety and Health
Washington, DC
ksouza@cdc.gov

Emily A. Spieler, JD

Hadley Professor of Law
Northeastern University
Boston, MA
e.spieler@neu.edu

Nancy A. Stout, EdD

Morgantown, WV
nancystout@comcast.net

Loren C. Tapp, MD, MS

Medical Officer
Hazard Evaluations and Technical
Assistance Branch
National Institute for Occupational
Safety and Health
Cincinnati, OH
let7@cdc.gov

Gregory R. Wagner, MD

Department of Environmental Health
Harvard T.H. Chan School of
Public Health
Boston, MA
Gwagner@hsph.harvard.edu

Elizabeth Ward, PhD

Former Senior Vice President,
Intramural Research
American Cancer Society
Atlanta, GA
eward04@gmail.com

Virginia M. Weaver, MD, MPH

Associate Professor
Departments of Environmental Health
and Engineering and Medicine
Associate Faculty Member
Welch Center for Prevention
Epidemiology and Clinical Research
Bloomberg School of Public Health
Johns Hopkins University
Baltimore, MD
vweaver1@jhu.edu

David H. Wegman, MD, MSc

Professor Emeritus
Department of Work Environment
University of Massachusetts Lowell
Adjunct Professor
Harvard T.H. Chan School of
Public Health
Cambridge, MA
David_Wegman@uml.edu

Laura S. Welch, MD

Medical Director
CPWR—The Center for Construction
Research and Training
Silver Spring, MD
lwelch@cpwr.com

Gavin H. West, MPH

Research Analyst
CPWR—The Center for Construction
Research and Training
Silver Spring, MD
gwest@cpwr.com

Sacoby Wilson, PhD, MS

Assistant Professor
Director, Community Engagement,
Environmental Justice, and Health
Maryland Institute for Applied
Environmental Health
School of Public Health
University of Maryland – College Park
College Park, MD
swilson2@umd.edu

Disclaimer

Authors' statements are independent of the institutions, agencies, or organizations with which they are affiliated.

Frequently Used Abbreviations

ANSI	American National Standards Institute
ATSDR	Agency for Toxic Substances and Disease Registry
BLL	blood lead level
BLS	Bureau of Labor Statistics
CDC	Centers for Disease Control and Prevention
CFOI	Census of Fatal Occupational Injuries
CT	computed tomography
EPA	Environmental Protection Agency
IARC	International Agency for Research on Cancer
ILO	International Labour Organization
IPCC	Intergovernmental Panel on Climate Change
ISO	International Organization for Standardization
MRI	magnetic resonance imaging
MSHA	Mine Safety and Health Administration
NCEH	National Center for Environmental Health
NIEHS	National Institute of Environmental Health Sciences
NIH	National Institutes of Health
NIOSH	National Institute for Occupational Safety and Health
NTP	National Toxicology Program
OSHA	Occupational Safety and Health Administration
PEL	permissible exposure limit
ppb	parts per billion
PPE	personal protective equipment
ppm	parts per million
REL	recommended exposure limit
SDS	safety data sheet
STEL	short-term exposure limit
TLV®	Threshold Limit Value
TWA	time-weighted average, usually averaged over an 8-hour work shift
WHO	World Health Organization

SECTION I

INTRODUCTION

Occupational and Environmental Health Challenges and Opportunities

Barry S. Levy, David H. Wegman, Sherry L. Baron,
and Rosemary K. Sokas

Occupational and environmental health comprises the recognition, diagnosis, treatment, and prevention of illnesses, injuries, and other adverse health conditions resulting from hazardous environmental exposures in the workplace, the home, and the community. Multidisciplinary in nature, occupational and environmental health is a component of both clinical care and public health.

THE WIDE SPECTRUM OF CHALLENGING SITUATIONS

There are many challenging situations for occupational and environmental health, as illustrated by the following examples:

A 2-year-old girl, during a routine well-child checkup, is found to have an elevated blood lead level of 20 µg/dL. As part of her care and to prevent further adverse effects of lead, what needs to be done to determine if the source of the lead is deteriorating lead-containing paint in her home, the water supply in her community, or her father's work in a smelter?

A pregnant woman, who works as a laboratory technician, is regularly exposed to organic solvents at work. Should her nurse-midwife recommend that

she change her job because of this exposure? How should the nurse-midwife address other toxic exposures, such as mercury in the fish that this woman regularly eats?

The wife of an asbestos-exposed pipefitter develops a pleural mesothelioma. How likely is it that this disease was caused by her washing her husband's dusty workclothes for many years? Can she or her family receive any compensation from her husband's employer or the companies that manufactured the asbestos to which they were exposed?

An oncologist observes an unusual cluster of 10 bladder cancer cases in a small town. To whom should she report this observation? Should she request an investigation to determine if some or all of these cases were due to a hazardous exposure that should be controlled?

Several members of a family, who live a half-mile from a hazardous waste site, smell odors from the site and report that they are experiencing headaches, dizziness, nausea, and other symptoms. As their primary care physician, what should you do?

The owner of a small nail salon is concerned about the possible health effects of chemicals used there. Where can she obtain helpful information and other resources?

These are but a few of the many occupational and environmental health challenges facing health-care practitioners, all of whom need to recognize and help prevent occupational and environmental health problems.

Many hazardous exposures occur simultaneously in the workplace and the ambient environment, including in the following situations:

- Contamination of ambient air and surface water near a chemical factory, whose workers are also exposed to hazardous substances
- Application by agricultural workers of pesticides that may contaminate surface water and groundwater
- Inadvertent transport of lead, asbestos, and other hazardous substances from the workplace to home on workers' clothes, shoes, skin, and hair.

While the workplace and the ambient environment present many hazards, as reflected throughout this book, they also provide many benefits that potentially contribute to health and well-being. The workplace provides opportunities for people to advance their knowledge and skills, contribute to society, and financially support themselves and their families. The environment provides opportunities for exploration and learning, recreation and relaxation, and communing with nature and appreciating the ecological context in which we live.

EVOLUTION OF OCCUPATIONAL HEALTH AND ENVIRONMENTAL HEALTH

Occupational health and environmental health evolved along separate—but often related—tracks. Hippocrates recognized the importance of air quality for health, although he was concerned only with the few Greeks who were “citizens”—not for the slaves or the free workers who supported them. Pliny the Elder recognized the ill effects of lead on slaves who painted ships in the Roman Empire in the first century A.D.; however, the use of lead in making cookware, sweetening foods, and souring vintages has persisted for 2,000 years.

Occupational hazards were not addressed systematically until 1700, when Bernardino

Ramazzini, an Italian physician, published *De Morbis Artificum Diatriba* (*On the Diseases of Workers*). Evolution of these related fields continued in the 20th century. Starting in the 1920s, Alice Hamilton, an American physician and colleague of the social reformer Jane Addams, pioneered occupational health as a specialty of public health and preventive medicine. In the 1960s, Rachel Carson, an American biologist and ecologist, focused public attention on the wide impact of hazardous agricultural chemicals in her landmark book, *Silent Spring*.

During the past 50 years, extraordinary developments in science, technology, legislation, public health, and social empowerment have led to much progress in both occupational health and environmental health. During this period, there have been more frequent interactions between these two fields and increasing recognition of fundamental areas of overlap in occupational and environmental health research as well as in community- and workplace-based interventions.

Historically, knowledge about adverse health effects of toxic environmental exposures in people has primarily resulted from research on occupational exposures. Workers have been more intensely exposed to specific known hazards than community residents and may have been exposed in the same workplaces throughout their work careers. By contrast, nonoccupational exposures to community residents have been more difficult to characterize and track, and individuals move from one community to another. Although community exposures are generally lower than occupational exposures, they occur throughout the day and night, rather than being confined to work shifts. In addition, community exposures may affect people who are too young, too old, too sick, or too disabled to work. And community exposures may include different routes of exposure than occupational exposures. Therefore, scientific findings from occupational health research alone cannot protect the general population from environmental exposures.

THE U.S. WORKFORCE

Table 1-1 lists the numbers of workers on nonfarm payrolls in the United States by major

Table 1-1. Employees on Nonfarm Payrolls by Major Industry Sector, Seasonally Adjusted, United States, May 2017

Industry Sector	Size of Workforce (in millions)
Services	65.2
Professional and business services	20.6
Educational services	3.6
Healthcare and social assistance	19.4
Leisure and hospitality	15.9
Other services	5.7
Government	22.3
Wholesale and retail trade	21.7
Manufacturing	12.4
Financial activities	8.4
Construction	6.9
Transportation and warehousing	5.1
Information	2.7
Mining and logging	0.7
Utilities	0.6
Total	146.1

Source: Bureau of Labor Statistics, U.S. Department of Labor. Available at: <http://www.bls.gov/news.release/empsit.t17.htm>. Accessed June 20, 2017.

industry sector. In recent decades in the United States, the percentage of workers in the manufacturing sector (Figure 1-1) has decreased and the percentage of workers in the service sector (Figure 1-2) has increased. This change means that occupational health practitioners are responding to a different mix of hazards and resultant illnesses and injuries. For example, the increasing number of workers in healthcare are more likely to face biological hazards (Chapter 13) compared to manufacturing workers.

CATEGORIES OF HAZARDS

Occupational and environmental hazards can be categorized as:

1. *Safety hazards*, which result in injuries through the uncontrolled transfer of energy to vulnerable recipients from sources such as electrical, thermal, kinetic, chemical, or radiation energy. Examples include unsafe playground equipment; loaded firearms in the home; causes of motor-vehicle or bicycle crashes; unprotected electrical sources and equipment; work at heights without fall protection; cluttered homes, leading to

slips, trips, and falls; unguarded machinery in operation; and work in unshored trenches. (See Chapter 19.)

2. *Health hazards*, which result in acute illnesses or chronic disorders (Chapters 20 through 28):
 - a. *Chemical hazards*, including heavy metals, such as lead and mercury; pesticides; organic solvents, such as benzene and trichloroethylene; and many other chemicals. Since 1979, approximately 85,000 chemicals have been, at some point, in commercial use in the United States;¹ however, the vast majority have not been adequately tested for adverse health effects.² (See Chapter 11.)
 - b. *Physical hazards*, such as excessive noise, vibration, extremes of temperature and pressure, and ionizing and non-ionizing radiation. (See Chapters 12A through 12D.)
 - c. *Biomechanical hazards*, such as heavy lifting and repetitive or forceful movements, that cause musculoskeletal disorders, such as chronic low back pain and carpal tunnel syndrome (Figure 1-3). (See Chapters 8 and 20.)
 - d. *Biological hazards*, such as hepatitis B virus and hepatitis C virus, the tubercle bacillus, and many other microorganisms that may be transmitted through direct contact, air, water, or food (Figure 1-4). (See Chapter 13.)
 - e. *Psychosocial hazards*, including (i) socioeconomic stressors, such as discrimination, income inequality, migration or immigration status, and unemployment, and (ii) job and organizational stressors, such as excessive demands on and low control by workers, job insecurity, and inadequate job training and retraining opportunities (Figures 1-5 and 1-6). (See Chapter 14.)

MAGNITUDE OF PROBLEMS

Occupational and environmental disorders occur frequently, but the accuracy of morbidity and mortality data varies widely. For example,



Figure 1-1. Worker at a wheel stamping plant. (Photograph by Earl Dotter.)



Figure 1-2. Home care worker with homebound patient. (Photograph by Earl Dotter.)



Figure 1-3. Garment workers are at increased risk of musculoskeletal disorders. (Photograph by Earl Dotter.)

population-based data on fatal injuries are generally thought to be more accurate than data on chronic occupational and environmental illnesses.

Occupational Injuries and Illnesses

Mandated systems for counting injuries and illnesses at work offer some estimates of the adverse health impacts of employment. These systems provide useful information on trends, but generally not accurate information on magnitude because of underreporting.^{3,4} (See Chapter 6.) In the United States in 2015, government reporting systems indicated that 4,836 workers died from occupational injuries—on average, about 13 a day—the highest number since 2008.⁵ These systems also estimated that approximately 50,000 workers die from work-related illnesses each year—although this estimate was based on very limited data.^{6,7} In 2015, employers reported approximately 2.9 million nonfatal workplace injuries and illnesses in private industry (3.0 cases per 100 equivalent full-time workers) and 722,000 in state and local government; about half of injured workers took time away from work or were transferred or placed on work restrictions.⁸ In 2015, an estimated 2.7 million workers were treated in emergency departments for work-related injuries, resulting in 113,000 in-patient hospital admissions.⁹ (See Chapter 19.) In low- and middle-income countries (LMICs), the rates of fatal and non-fatal occupational injuries and illnesses have been much higher than in the United States. (See Chapter 35.)



Figure 1-4. Laundry workers are exposed to biological hazards, such as sharps in soiled bed linens. (Photograph by Earl Dotter.)



Figure 1-5. Migrant workers picking cotton face many challenges because of their minority status, poverty, inadequate education, and lack of information on and inadequate control over the agrochemicals to which they are exposed. (Photograph by Earl Dotter.)

Work-related injuries and illnesses are costly. In 2014, employers in the United States spent an estimated \$91.8 billion on workers' compensation insurance costs.¹⁰ However, this amount represents only part of all work-related injury and illness costs borne by employers, workers, and society overall—largely because

the costs of many injuries and most illnesses are shifted to other health insurance systems. Thousands of workers become temporarily or permanently disabled from work-related injuries in the United States each day, but only a small percentage of them receives workers' compensation.

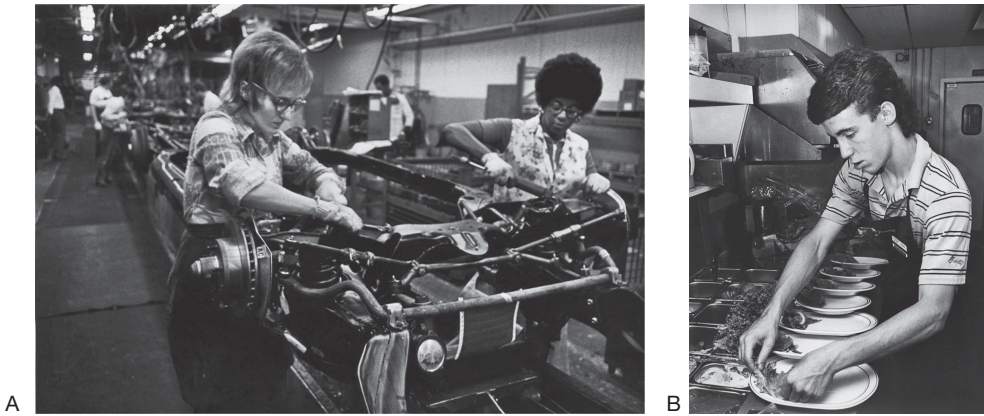


Figure 1-6. Workers exposed to occupational stressors, such as fast-paced work, include (A) assembly-line workers, and (B) short-order cooks. (Photographs by Earl Dotter.)

Table 1-2. Subjects of Environmental Health Objectives for 2020, United States

Subjects	Subtopics
Outdoor Air Quality	Air Quality Index Alternative modes of transportation for work
Water Quality	Airborne toxins Safe drinking water Waterborne disease outbreaks Water conservation
Toxics and Waste	Safety of beaches for swimming Elevated blood lead levels in children Risks posed by hazardous waste sites Pesticide exposures Toxic pollutants released into the environment Recycling of municipal solid waste
Healthy Homes and Healthy Communities	Indoor allergens Radon mitigation School policies to promote healthy and safe physical school environments Lead-based paint and related hazards Housing with physical problems
Infrastructure and Surveillance	Exposure to heavy metals, pesticides, and other hazardous chemicals in the environment Information systems for environmental health Monitoring for environmentally related diseases
Global Environmental Health	Global burden of disease due to poor water quality, sanitation, and insufficient hygiene

Source: Available at: <https://www.healthypeople.gov/2020/topics-objectives/topic/environmental-health>. Accessed January 2, 2017.

Environmental Health Hazards

The scope of environmental health hazards is broad, as partially reflected in the subjects of the environmental health objectives for the United States for 2020 (Table 1-2). Outdoor air pollution remains a widespread environmental and public health problem,

causing chronic impairment of the respiratory and cardiovascular systems, cancer, and premature death (Figure 1-7; see also Chapter 15). The Environmental Protection Agency (EPA), under the provisions of the Clean Air Act, set health-based standards (the National Ambient Air Quality Standards) for six “criteria air pollutants”: particulate matter, ground-level ozone,



Figure 1-7. Outdoor air pollution from a coal-cleaning plant. (Photograph by Earl Dotter.)

sulfur dioxide, lead, nitrogen dioxide, and carbon monoxide. More than 100 million people in the United States reside in “nonattainment areas,” locations that do not meet one or more of these standards.¹¹ Motor vehicles and electrical power plants account for much ambient air pollution.

Water quality continues to be a problem from both point sources, such as industrial sites, and nonpoint sources, such as agricultural runoff (Figure 1-8; see also Chapter 16). Toxic and hazardous substances, in addition to posing health problems for exposed workers, may also cause health problems to people exposed where they live and elsewhere. Hydraulic fracturing (fracking) to release petroleum and natural gas from shale, a process that is increasingly used in the United States to enhance the energy supply, is also raising concerns about water quality. Other concerns about fracking include noise from the extraction process, increased heavy equipment traffic, increased frequency of earthquakes, and the adverse impact of continued reliance on fossil fuels on global climate change.

Children are at increased risk for many environmental health problems because (a) their



Figure 1-8. Water pollution from a plant that manufactured bleached white paper. (Photograph by Earl Dotter.)

neurological and other systems are still in development, (b) they absorb substances and metabolize them differently than adults, and (c) they may be at risk for increased exposure from hand-to-mouth activity or improper storage of chemicals. (See Chapter 30.) Other environmental health hazards include poor indoor air quality (Chapter 15), lead-based paint (Figure 1-9), lead-contaminated drinking water, household cleaning products, mold, radon, and electrical and fire hazards. Many environmental hazards are present in homes; for example, over 90% of toxic exposures reported to poison control centers in the United States occur in the home environment.

Environmental Illnesses and Injuries

There are fewer data on the occurrence of environmental disorders than occupational disorders. For some environmentally related disorders in the United States, such as childhood lead poisoning, there are extensive data from screening



Figure 1-9. Lead abatement workers. (Photograph by Earl Dotter.)

programs, which in 2015 showed that 11,681 (0.5%) of the 2.4 million tested children under 6 years of age had blood lead levels (BLLs) that were 10 $\mu\text{g}/\text{dL}$ or higher, and 79,955 (3.3%) had BLLs that were 5 $\mu\text{g}/\text{dL}$ or higher.¹² However, since most of those tested were likely at elevated risk of lead exposure, these results cannot be projected to estimate the total U.S. burden of excessive lead exposure on children. Data on pesticide poisoning are very limited; many cases go unreported because of the nonspecificity of symptoms and occurrence of pesticide poisoning not related to agriculture. In 2014 in California, the state with the most extensive reporting system for pesticide poisoning, 74% of the 1,073 reported cases were due to non-agricultural pesticide use.¹³

In contrast, there are extensive data available to estimate the numbers of acute injuries in the home, on the road, and in other nonoccupational settings due to various causes, such as motor vehicles and firearms. In the United States in 2014, fatal unintentional injuries (135,928) were the fourth leading cause of death, accounting for 5.2% of deaths nationwide.^{14,p.5} In 2014, there were 42,032 deaths due to unintentional poisoning, 33,736 motor vehicle traffic deaths, 31,959 unintentional fall deaths, and 461 unintentional firearm deaths (of a total of 33,594 firearm deaths).^{14,p.87}

There is substantial respiratory morbidity and mortality related to outdoor and indoor air contaminants. In the United States in 2014, the prevalence of asthma in children was 8.6% and, in

adults, 7.4%.¹⁵ Environmental causes of asthma include outdoor air pollution, environmental tobacco smoke, and many allergens, including those disproportionately associated with substandard housing, such as mold and cockroach antigen (Chapter 22).

Under-recognition or Underreporting of Illnesses and Injuries

Many occupational and environmental health problems escape detection because of several factors (Figure 1-10):

1. Many problems do not come to the attention of health professionals, employers, and others and therefore are not included in data collection systems. A worker or community resident may not recognize a health problem as being occupationally or environmentally related; some workers may be afraid of possible retaliation and job loss if they recognize or report an occupational illness or injury. Educating workers and community residents about hazards, such as with workplace and community-based right-to-know programs, helps to improve recognition of disorders caused by occupational or environmental exposures. Although federal regulations prohibit retaliation against workers for reporting hazards or outcomes, rigorous enforcement of these regulations depends, in part, on labor unions and other worker advocacy organizations.

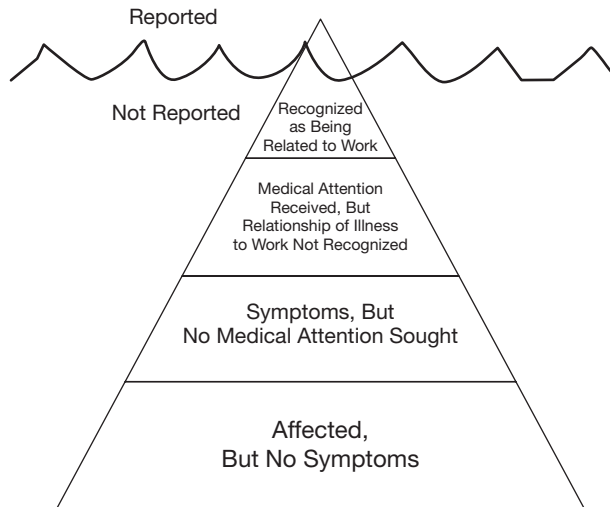


Figure 1-10. Most occupational and environmental disorders are below the surface.

2. Many health problems that *do* come to the attention of physicians, employers, and others are not recognized as occupationally and environmentally related. Recognition of occupational and environmental disorders is often difficult because of the long period between initial exposure and onset of symptoms (or time of diagnosis), making cause-and-effect relationships difficult to determine in groups or individuals. Recognition is also difficult because many people are exposed to multiple occupational and environmental hazards.
3. Some health problems that *are* recognized by health professionals, employees, or others as occupationally or environmentally related are not reported because the association with the workplace or other environments is not certain or because reporting requirements are not enforced. For example, only a few states require that physicians report cases of pesticide poisoning. (See Chapter 6.) One approach to address this problem at the federal level has been providing public access to information.

In addition, many occupational and environmental health problems that *are* reported are not adequately investigated and controlled because

of limited resources, inadequate development and enforcement of regulations, and opposition by those who are legally and/or financially responsible for the development and/or persistence of these problems.

CONTEXT

Occupational and environmental health problems can be understood in social, ecological, economic, political, and historical contexts. Those whose actions determine the broader structural context include workers, employers, representatives of business and labor organizations, community residents, members of environmental nongovernmental organizations, officials of government agencies and international organizations, educators and trainers, researchers, journalists, and representatives of foundations. These “actors” play multiple roles, rely on various sources of power and support, have specific strengths and vulnerabilities, and engage in complex sets of interactions with each other in multiple ways. Health and safety professionals and many other actors are engaged in the recognition, assessment, treatment, and prevention of occupational and environmental health problems within this broad context.

RECOGNITION AND PREVENTION

The first and most important step in diagnosis and treatment of an occupational or environmental illness or injury is the recognition that it is potentially caused by an occupational or environmental exposure. Recognition focuses both on (a) detecting occupational and environmental illnesses and injuries in symptomatic and asymptomatic individuals (Chapter 4), and (b) conducting public health surveillance in populations to detect individual cases and overall trends of illness and injury (Chapter 6).

Prevention consists of:

- *Primary prevention:* Preventing illnesses and injuries before they occur
- *Secondary prevention:* Identifying and treating health problems as early as possible, often before symptoms have developed or permanent impairment has occurred
- *Tertiary prevention:* Implementing interventions to arrest the progress of established diseases, injuries, or their consequences, including disability.

A useful paradigm to identifying opportunities for prevention and designing preventive measures is the public health model of host, agent, and environment. First, some preventive measures focus on a host or hosts—workers or community residents; these measures include education and training, providing immunizations or post-exposure prophylaxis, monitoring personal exposures, screening for early detection of disease, and use of personal protective equipment. Second, some preventive measures focus on the agent (hazard), such as an asbestos-containing product, and restricting or banning its production or use in order to reduce exposure. And third, some preventive measures focus on the environment, including engineering measures, such as local exhaust ventilation to remove airborne hazards in the workplace, placement of sound-barrier walls alongside highways to reduce noise in adjacent neighborhoods, and urban planning to create more green space or bicycle lanes. (See Chapters 4 and 8.)

CHANGING NATURE OF WORK AND THE WORKFORCE

Major changes in work structure have occurred in recent years, including company mergers, automated production, and outsourcing. In the United States, there have been significant changes within industries. For example, within agriculture, the number of poultry, beef, and pork producers has decreased while the size of these producers has grown. The number of family farms has decreased while the number of concentrated animal feeding operations, with large-scale production and mechanized processes, has increased—causing concerns about exploitation of workers, animal welfare, environmental contamination from concentrated waste, and production of greenhouse gases. Meat packaging and poultry processing plants have relocated near large producers, and the demographics of their workers has typically been transformed from relatively highly paid, unionized, mostly white workers to immigrant Latino workers who face poor working conditions, receive low pay, change jobs often, and infrequently belong to labor unions. In addition, one-third of those working in meat-processing plants are contingent workers, who work for subcontracting agencies and perform such tasks as cleaning and maintenance. Although these workers often face occupational hazards, workers' compensation systems and Occupational Safety and Health Administration (OSHA) standards often fail to address their needs. Similarly, many unauthorized immigrants work under informal work arrangements or as day laborers—without adequate legal protection. Reliance on contingent workers and outsourced work occurs throughout the U.S. economy, from healthcare to manufacturing to information technology. (See Chapter 2.)

During the past four decades in the United States, there has been a shift in the economy, with many more jobs created in the service sector than in manufacturing. This shift has resulted from both transfer of manufacturing to LMICs and developments in engineering technology that have produced increased efficiencies within manufacturing. Advances in information technology and in automation and robotics have reduced the number of jobs in the service and manufacturing sectors that pay good wages and

provide health benefits and paid leave. There are not enough worker training and retraining programs available to help displaced workers learn the skills that they need in order to find employment in higher-technology industries.¹⁶

Accompanying these changes have been changes in the nature of work due to the *fissured workplace*, in which businesses, including large corporations, are not serving as direct employers of their workers but rather subcontracting work to smaller companies where competition can be harsh and the quality of jobs is low. In doing so, these companies typically avoid paying appropriate benefits to workers and tend to ignore occupational health and safety.¹⁷ These nonstandard work arrangements have profound impacts on worker health and safety.¹⁸ The presence of multiple levels of this type of subcontracting creates confusion regarding which businesses or other entities are responsible for protecting the health and safety of workers. As a result, wages have been declining, benefits have been eroding, workplace health and safety have not been adequately protected, and income inequality has continued to widen. Other major changes have included an increased number of women working outside the home; therefore, there have been increased needs both for professionals in child care and elder care and service-sector workers, such as in fast-food restaurants. Women are working in many of the jobs created by these needs.¹⁹

Another development has been the aging of the workforce, in parallel with the aging of the U.S. population. This development has been coupled with changing patterns of retirement, partly due to changes in retirement benefits. In 2016, almost 20% of people 65 years of age and older were working—the highest proportion since before Medicare was enacted in 1965.²⁰ Older workers are living longer, needing income, often like their jobs, and are often appreciated by employers who recognize what older workers can offer. From a health and safety perspective, older workers bring experience and expertise to the job, but they have to accommodate or adjust to gradual physiological and cognitive changes that accompany aging, they may face age discrimination, and they sustain more severe outcomes when injuries occur.²¹

Specific needs that have arisen from the changing nature of work and the workforce include (a) integrating family health with work schedules, recognizing that work-related stresses extend to the home environment, and (b) accommodating workers who have significant skills but reduced physical capacity, visual acuity, or other impairments. Advances in healthcare have increased the numbers of workers with functional limitations who are able to contribute to society and have the right to work, a right protected by the Americans with Disabilities Act. All of the challenges posed by the changing nature of work and the workforce can be met by preventive measures that are supported by laws and regulations, employment policies, education and research, and public health and clinical practice. (See Chapters 2, 3, and 10.)

Advances in Technology

In addition to transforming the workplace through robotics, advances in technology have introduced new potentially hazardous substances, such as nanomaterials, that are contaminating the workplace and the ambient environment (Chapter 8). Technological innovation has also led to important advances in occupational and environmental health research. For example, new methods can facilitate identification of potential workplace hazards, including new and improved assays to determine the possible carcinogenicity of substances and to measure concentrations of hazardous substances or their metabolites in body fluids (Chapter 21). In addition, advances in technology have introduced potentially hazardous substances or their metabolites in body fluids.

Promoting a Healthy Workforce

Work-related factors, such as wages, hours of work, and access to paid or unpaid sick leave, in addition to hazardous and stressful work environments, impact the well-being of workers, their families, and their communities. Recently, there has been broader acknowledgement that the workplace can contribute to health problems in ways that were previously not recognized as “work-related,” such as contributing

to sleep disorders, cardiovascular disease, obesity, and anxiety and depression. The NIOSH Total Worker Health® Program is advancing research to create prevention recommendations that employers and others can use to develop workplace policies, programs, and practices that improve worker health and well-being.²²

Occupational and Environmental Health Services and Primary Healthcare

Despite limited resources and infrastructure, some safety-net primary care providers are exploring ways to integrate occupational and environmental health services with primary medical care and with a broader range of public health services. Although some successes have been achieved with this approach, there remains much untapped potential in fully achieving this integration. Electronic health records (EHRs) provide new opportunities to integrate occupational health information. For example, through clinical decision support systems, EHRs can deliver specific information related to diagnosing occupational asthma and to managing work-related factors, such as shift work, that can present challenges to management of diabetes.

EVOLVING ROLES OF GOVERNMENT

Governmental regulatory and research agencies in occupational health and those in environmental health have evolved over decades, generally with limited connection between agencies in these two fields. With the passage of laws that established the Mine Safety and Health Administration in 1969 and OSHA and the EPA in 1970, the federal government took an active role in setting and enforcing standards for a safe and healthful workplace and a safe and healthful ambient environment. (See Chapter 3 and parts of Chapters 15 through 18.) After promulgation of standards (regulations) in the 1970s, legal and political challenges slowed the setting of new standards and federal budget cuts often limited enforcement of existing standards. To help accomplish their core missions, regulatory

agencies engage in outreach and technical assistance, such as OSHA's free On-site Consultation Program for small businesses and its provision of small grants for health and safety training. Important responsibilities in occupational health and environmental health are assumed by state and local government agencies, which vary considerably in size, resources, and levels of activity. These agencies closely interact with their counterparts at the federal level.

There are separate federal research agencies in occupational health, including the National Institute for Occupational Safety and Health, the National Center for Environmental Health, the Agency for Toxic Substances and Disease Registry, and the National Institute of Environmental Health Sciences. The EPA's Office of Research and Development also supports and conducts environmental health research. Over time, research has broadened to include community-based participatory research, which addresses environmental justice and related issues.

LIABILITY

Some workers, barred from suing their employers under workers' compensation laws, have filed *third-party lawsuits* (product-liability lawsuits) as a means of redress for occupational disease associated with specific agents or technologies; some community residents exposed to environmental hazards have also filed similar lawsuits (Chapter 3). Although these lawsuits may direct more attention to prevention, this approach may be cumbersome and outcomes may not be equitable. In recent years, plaintiffs and their attorneys have found it increasingly difficult to recover damages in such lawsuits for a variety of reasons, including federal and state court decisions as well as state laws that have restricted expert testimony or otherwise limited these lawsuits.

ENVIRONMENTAL JUSTICE

Attention to environmental justice has grown, with the recognition that disparities in environmental exposures between high-income and

low-income communities partially account for differences in health status among communities. The Environmental Justice Movement is comprised of organizations and people representing low-income and minority individuals who oppose placement of hazardous waste sites and polluting facilities in their communities. It has transformed the Environmental Movement from a campaign of middle-class people concerned about ecological issues to a grassroots movement of poor and working-class communities concerned mainly about preserving their health. Many environmental health professionals work with urban sociologists, economists, community activists, and others to develop programs to reduce or eliminate environmental disparities that contribute to health disparities. (See Chapter 2.)

THE BUILT ENVIRONMENT

Many people spend most of their time in or on “the built environment,” which includes homes, offices, industrial facilities, schools, roadways, sidewalks, parks, and even vehicles. All of these environments can increase or reduce risks for injuries; acute illnesses, such as exacerbations of asthma; and chronic disorders, such as obesity and diabetes. These environments also shape social, economic, and psychological well-being. Designing environments to promote physical activity, including walking, climbing of stairs, bicycling, and other forms of active transport, is a documented tool for public health improvement. (See Chapter 34.)

CLIMATE CHANGE

Climate change—or, more accurately, global climate disruption—is creating profound environmental consequences and adverse health effects. Environmental consequences include warmer temperatures and longer, more frequent, and more severe heat waves; extremes of precipitation, leading to droughts and floods; and sea-level rise, leading to more storm surges, coastal erosion, and saltwater incursion onto farmland and into groundwater. Direct adverse health

effects include heat-related disorders; respiratory and allergic disorders; vector-borne, water-borne, and foodborne infectious diseases; and injuries from extreme weather events. Indirect adverse health effects arise from food insecurity, distress migration, and collective violence that may be caused, or contributed to, by climate change. All of these consequences of climate change can cause mental health problems, including anxiety, depression, and posttraumatic stress disorders. Within the United States, the impact of climate change is greater on poor communities and on other vulnerable populations. Globally, high-income countries, which emit the most greenhouse emissions, tend to suffer the least from the consequences of climate change, and LMICs, which emit far lower levels of greenhouse emissions, tend to suffer the most. (See Chapter 29.)

NEW DIRECTIONS FOR RESEARCH

While extensive research continues on possible associations between hazardous exposures and illness, injury, and premature death, researchers are broadening the focus to new areas, including:

- The social determinants of health, investigating how these factors impact the health of workers and community residents
- Engaging community members to evaluate prevention programs on problems such as lead poisoning, childhood asthma, and physical fitness.

Emerging fields of research are exploring how *beneficial* “exposures” at work or in the natural environment may produce specific beneficial outcomes:

- How personal interaction with the natural environment may be associated with improved health and well-being^{23,24}
- How positive aspects of worksite organization, such as opportunities for training or supportive supervision, may be associated with positive outcomes, such as improved mental health or reduced cardiovascular mortality.^{25,26}

ECONOMIC GLOBALIZATION

The growth of multinational corporations, reduction in trade barriers, and development of regional treaty arrangements, such as the North American Free Trade Agreement, and global organizations, such as the World Trade Organization, have had a substantial adverse impacts on occupational and environmental health. In many LMICs, multinational corporations have exploited workers by employing them in jobs that have low wages and few benefits, offer little or no training or upward mobility, and expose them to health and safety hazards. Some regional trade agreements have included occupational and environmental health protections that have generally been poorly implemented and inadequately monitored. (See Chapter 35.)

ADDITIONAL CHALLENGES FOR LMICs

Low- and middle-income countries, which comprise two-thirds of all countries and include the vast majority of people globally, face additional challenges, as described briefly next.

Export of Hazard

High-income countries often export their most hazardous industries, hazardous materials (such as banned or restricted pesticides), and hazardous wastes—as well as tobacco products—to LMICs, where laws and regulations concerning these substances are more lax or nonexistent and where people may be less aware of these hazards.

Transnational Problems

Occupational and environmental health problems in LMICs often involve multiple countries in the same region, requiring transnational or regional approaches to problems, such as development and implementation of transnational standards.

Inadequate Infrastructure and Human Resources

In LMICs, there are far fewer adequately trained personnel to recognize, diagnose, treat, and

prevent occupational and environmental health problems. Governments and other sectors of society have fewer resources to devote to occupational and environmental health, and labor unions, facing other challenges such as low wages and high unemployment, often give little attention to occupational health and safety.

Relationship Between the Workplace and the Home Environment

In LMICs, where so many people work in or near their homes, the distinction between the workplace and the home environment is blurred. As a result, family members may often be exposed to workplace hazards, such as lead and pesticides.

Economic Development

Governments of LMICs often give high priority to economic development, sometimes even higher priority than to the health of their citizens. In the context of economic development, industrialization, and urbanization, there is often pressure to overlook occupational and environmental health issues, given limited resources and the fear that attention to these issues may drive away potential international investors or employers. Similarly, workers desperate for jobs in economies with high unemployment rates are unlikely to complain about health and safety hazards at work once they are employed. In addition, many children are forced to leave school in order to work, often in hazardous jobs. (See Chapter 35.)

SOCIAL AND ETHICAL QUESTIONS

Serious social and ethical questions have been raised over the allegiance of occupational and environmental physicians who are employed by management; workers' and communities' "right to know" about occupational and environmental hazards; confidentiality of workers' medical records maintained by employers; restriction of female workers of childbearing age from certain jobs; and other contentious issues. Some of the questions concerning these subjects may eventually be answered by labor-management and

community–company interactions and by the decisions of government bodies—courts, legislatures, and executive agencies. For example, the U.S. Supreme Court found that so-called “fetal protection” policies that excluded women of reproductive age from industrial jobs, where men were permitted to work, illegally discriminated on the basis of gender.^{27,28}

Ethics and ethical analyses help provide guides for action that are consistent; justifiable by appeal to commonly held values, principles, or roles; and able to withstand close moral scrutiny.²⁹ Conflict and disagreement are common in many aspects of occupational and environmental health. Difficult questions often arise, such as the following: What degree of risk should trigger action? What are the costs and benefits of regulating use of a substance or of screening workers for early detection of disease? How safe is safe enough? To what information are exposed workers or community residents entitled? How should decisions that impact health, environmental protection, and economic development be made? Not all aspects of the conflicts implied by these questions are ethical in nature, but most have some underlying ethical or moral dimension.³⁰ Occupational and environmental health professionals can refer to codes of ethics and other ethics guidelines of their professional organizations, including the American College of Occupational and Environmental Medicine, the American Association of Occupational Health Nurses, the American Board of Industrial Hygiene, the American College of Epidemiology, and the International Commission on Occupational Health—all of which are available on the Internet.

DISCIPLINES AND CAREERS IN OCCUPATIONAL AND ENVIRONMENTAL HEALTH SCIENCES

Identification and remediation of threats to the environment is a stewardship responsibility for us all. For those who work in clinical care or public health, there is a wide range of career options that span the physical, biologic, and social sciences as well as communications, policymaking, and other fields. A key challenge is communicating effectively across disciplines to develop

collaboration for safe, healthful, and sustainable environments for future generations.

Almost all healthcare providers encounter occupational and environmental health issues. The American College of Graduate Medical Education recognizes the specialty of preventive medicine, which includes three areas of expertise: public health and general preventive medicine, occupational medicine, and aerospace medicine. Physicians who choose to specialize in any of these areas may wish to become certified by the American Board of Preventive Medicine. (For criteria for certification, access the board’s website, <http://www.abpm.org>.) The American College of Occupational and Environmental Medicine is a primary professional association for physicians engaged in the practice of occupational and environmental medicine.

For those who wish to specialize in occupational and environmental health nursing, there are certificate programs, advanced degree programs for nurse practitioners that offer the Master of Science in Nursing (MSN), and doctoral programs, which include the Doctor of Philosophy (PhD) degree for those interested in research and the Doctor of Nursing Practice (DNP), an advanced professional practice degree. The American Association of Occupational Health Nurses is the primary professional association for occupational health nurses.

Physicians’ assistants are midlevel practice professionals who are trained typically in an applied master of science degree program. They form the practice core for several large occupational health programs in industry and in the Veterans Administration health system.

Other healthcare professions important to the field of environmental and occupational health include audiology, physical therapy and rehabilitation, clinical psychology, clinical social work, and optometry. Occupational health psychologists apply psychology to improving the quality of work life and to protecting and promoting the safety, health, and well-being of workers.

A wide range of environmental health science programs are available at levels ranging from community colleges to postgraduate doctoral programs, with credentialing (based on education, experience, and certifying examinations)

available for registered environmental health specialists, sanitarians, environmental health technicians, food-safety professionals, hazardous-substance professionals, and others.

Engineering and public health programs overlap in the training of industrial hygienists and environmental engineers, who provide primary prevention through exposure assessment as well as design and implementation of interventions. Radiation physicists and biologists address a specific aspect of environmental and occupational exposure assessment and prevention.

Safety professionals have education in engineering disciplines, often with additional management training. Bachelor's, master's, and doctoral degree programs are available. Public health practitioners are also trained through Master of Public Health degree and other programs.

Research into any of the occupational and environmental health sciences can form the basis for a doctoral program that focuses on advancement of scientific knowledge. These sciences include toxicology, epidemiology, environmental chemistry, systems engineering, sociology, psychology, and anthropology. Communications science, including social marketing and journalism, represents an important related area of study and practice. Environmental law, economics, policy, urban planning, and environmental management are other important areas of work. Finally, ecology, agronomy, chemistry, physics, and geology, which do not directly address human health impacts, are nevertheless critical to understanding the environment and human impact on it. These disciplines provide additional career opportunities related to occupational and environmental health.

REFERENCES

1. Denison R. We don't know how many chemicals are in use today. We should know. EDF Health, July 13, 2015. Available at: <http://blogs.edf.org/health/2015/07/13/we-dont-know-how-many-chemicals-are-in-use-today-we-should-know/>. Accessed January 3, 2017.
2. U.S. Environmental Protection Agency. Final Contaminant Candidate List 3 chemicals: Identifying the universe. August 2009. Available at: https://www.epa.gov/sites/production/files/2014-05/documents/ccl3_chemicals_universe_08-31-09_508_v3.pdf. Accessed January 3, 2017.
3. Fagan KM, Hodgson MJ. Under-recording of work-related injuries and illnesses: An OSHA priority. *Journal of Safety Research* 2017; 60: 79–83.
4. Ruser JW. Examining evidence of whether BLS undercounts workplace injuries and illnesses. *Monthly Labor Review*, August 2008.
5. Bureau of Labor Statistics. Census of fatal occupational injuries—Current and revised data. Available at: <https://www.bls.gov/iif/oshcoi1.htm>. Accessed January 1, 2017.
6. Steenland K, Burnett C, Lalich N, et al. Dying for work: The magnitude of U.S. mortality from selected causes of death associated with occupation. *American Journal of Industrial Medicine* 2003; 43: 461–482.
7. Leigh JP. Economic burden of occupational injury and illness in the United States. *Milbank Quarterly* 2011; 89: 728–772.
8. Bureau of Labor Statistics. Employer-reported workplace injuries and illnesses—2015. October 27, 2016. Available at: <http://www.bls.gov/news.release/pdf/osh.pdf>. Accessed January 1, 2017.
9. National Institute for Occupational Safety and Health. Unpublished data, 2016. (Cited in Centers for Disease Control and Prevention Workers' Memorial Day—April 28, 2016. *Morbidity and Mortality Weekly Report* 2016; 65: 389.)
10. National Academy of Social Insurance. Press release: Workers' compensation benefits as a share of payroll continue to decline even as employer costs rise. October 5, 2016. Available at: <https://www.nasi.org/press/releases/2016/10/press-release-workers%E2%80%99-compensation-benefits-share-payrol>. Accessed January 1, 2017.
11. U.S. Environmental Protection Agency. Summary nonattainment area population exposure report. September 22, 2016. Available at: <https://www3.epa.gov/airquality/greenbook/popexp.html>. Accessed January 2, 2017.
12. Centers for Disease Control and Prevention. Lead: CDC's national surveillance data (1997–2015). Available at: <https://www.cdc.gov/nceh/lead/data/national.htm>. Accessed January 1, 2017.
13. California Environmental Protection Agency. Summary of results from the California Pesticide Illness Surveillance Program—2014. Sacramento: California Environmental Protection Agency, December 14, 2016, p. 1.

14. Kochanek KD, Murphy SL, Xu J, Tejada-Vera B. Deaths: Final data for 2014. *National Vital Statistics Reports* 2016; 65: 1–122.
15. Centers for Disease Control and Prevention. Asthma: Most recent asthma data. Available at: https://www.cdc.gov/asthma/most_recent_data.htm. Accessed January 1, 2017.
16. Talbot D. “Tectonic shifts” in employment. *MIT Technology Review*, December 20, 2011.
17. Weil D. *The fissured workplace: Why work became so bad for so many and what can be done to improve it*. Cambridge, MA: Harvard University Press, 2014.
18. Howard J. Nonstandard work arrangements and worker health and safety. *American Journal of Industrial Medicine* 2017; 60: 1–10.
19. Urquhart M. The employment shift to services: Where did it come from? *Monthly Labor Review*, U.S. Department of Labor, April 1984.
20. Steverman B. “I’ll never retire”: Americans break record for working past 65. *Bloomberg News*, May 13, 2016. Available at: <https://www.bloomberg.com/news/articles/2016-05-13/-i-ll-never-retire-americans-break-record-for-working-past-65>. Accessed January 20, 2017.
21. National Center for Chronic Disease Prevention and Health Promotion. Older employees in the workplace: Issue brief no. 1, July 2012. Atlanta: Centers for Disease Control and Prevention.
22. National Institute for Occupational Safety and Health. Fundamentals of total worker health approaches: Essential elements for advancing worker safety, health, and well-being (DHHS [NIOSH] Publication Number 2017-112). December 2016. Available at: <https://www.cdc.gov/niosh/docs/2017-112/>. Accessed January 30, 2017.
23. Wang D, Lau KK, Yu RH, et al. Neighbouring green space and all-cause mortality in elderly people in Hong Kong: A retrospective cohort study. *Lancet* 2016; 388: S82.
24. Dadvand P, Sunyer J, Alvarez-Pedrerol M, et al. Green spaces and spectacles use in schoolchildren in Barcelona. *Environmental Research* 2017; 152: 256–262.
25. Milner A, Krnjack L, LaMontagne AD. Psychosocial job quality and mental health among young workers: A fixed-effects regression analysis using 13 waves of annual data. *Scandinavian Journal of Work, Environment & Health* 2017; 43: 50–58.
26. Kivimäki M, Ferrie JE, Brunner E, et al. Justice at work and reduced risk of coronary heart disease among employees: The Whitehall II Study. *Archives of Internal Medicine* 2005; 165: 2245–2251.
27. United States Supreme Court. *United Auto Workers, et al. v. Johnson Controls, Inc.*, 499 U.S. 187, 111 S. Ct. 1196, 113 L. Ed. 2d 158 (1991).
28. Clauss CA, Berzon M, Bertin J. Litigating reproductive and developmental health in the aftermath of UAW versus Johnson Controls. *Environmental Health Perspectives* 1993; 101(Suppl 2): 205–220.
29. Beauchamp TL, Childress JF. *Principles of biomedical ethics*. New York: Oxford University Press, 1983.
30. Rest KM. Ethics in occupational and environmental health. In: BS Levy, DH Wegman (eds.). *Occupational health: Recognizing and preventing work-related disease* (3rd ed.). Boston: Little, Brown and Company, 1995, pp. 241–258.

FURTHER READING

Selected Books

- Baxter PJ, AW T-C, Cockcroft A, et al. (eds.) *Hunter’s diseases of occupations* (10th ed.). Boca Raton, FL: CRC Press, 2010.
A classic textbook on occupational diseases.
- Burgess W. *Recognition of health hazards in industry: A review of materials and processes* (2nd ed.). New York: John Wiley & Sons, 1995.
An excellent summary of industrial hazards and how things work.
- Frumkin H (ed.). *Environmental health: From global to local* (3rd ed.). San Francisco, CA: Jossey Bass, 2016.
A comprehensive introductory textbook.
- Hamilton A. *Exploring the dangerous trades: An autobiography*. Boston: Little, Brown, 1943.
(Also published by OEM Press in 1995.)
A classic historical reference.
- Hathaway GJ, Proctor NH. *Proctor and Hughes’ chemical hazards of the workplace* (5th ed.). Hoboken, NJ: John Wiley & Sons, 2004.
Brief summaries of many chemical hazards, including basic information about their chemical, physical, and toxicologic characteristics; diagnostic criteria; treatment; and medical control measures.
- LaDou J, Harrison R (eds.). *Current occupational and environmental medicine* (5th ed.). New York: McGraw-Hill Medical, 2014.
A clinically focused guide on common occupational and environmental illnesses.
- Rom WN, Markowitz SB (eds.). *Environmental & occupational medicine* (4th ed.). Philadelphia: Wolters Kluwer/Lippincott Williams & Wilkins, 2007.

An excellent, comprehensive, in-depth reference on occupational and environmental medicine.

Stellman JM (ed.). *Encyclopaedia of occupational health and safety* (5th ed.). Geneva: International Labor Organization, 2012.

An online multidisciplinary book on occupational hazards and disorders and related subjects.

Stave GM, Wald PH (eds.). *Physical and biological hazards of the workplace* (3rd ed.). Hoboken, NJ: John Wiley & Sons, 2016.

A practical reference on the diagnosis, treatment, and control of these hazards.

Selected Periodical Publications

Occupational and Environmental Health

American Journal of Industrial Medicine, published monthly by Wiley-Liss, Inc.

American Journal of Public Health, published monthly by the American Public Health Association

Environmental Health Perspectives, published monthly by the National Institute of Environmental Health Sciences

Journal of Occupational and Environmental Medicine, the journal of the American College of Occupational and Environmental Medicine, published monthly by Wolters Kluwer Health/Lippincott Williams & Wilkins

New Solutions: A Journal of Occupational and Environmental Health Policy, published quarterly by SAGE Publications

Occupational and Environmental Medicine, the journal of the Faculty of Occupational Medicine of the Royal College of Physicians of London, published monthly by the BMJ Publishing Group, Ltd.

Scandinavian Journal of Work, Environment & Health, published every other month by the Nordic Association of Occupational Safety and Health

Occupational Health Nursing

American Association of Occupational Health Nurses Journal, published monthly by the American Association of Occupational Health Nurses

Occupational and Environmental Hygiene

Journal of Occupational and Environmental Hygiene, published monthly by the American Industrial Hygiene Association and ACGIH

Annals of Work Exposures and Health, the journal of the British Occupational Hygiene Society, published every other month by Oxford University Press

Occupational Safety

Professional Safety, published monthly by the American Society of Safety Engineers

Journal of Safety Research, published monthly by the National Safety Council and Elsevier

Accident Analysis & Prevention, published monthly by Elsevier

Injury Prevention, the official journal of the Society for Advancement of Violence and Injury Research, published every other month by BMJ

Occupational Ergonomics

Applied Ergonomics: Human Factors in Technology and Society, published every other month by Elsevier

Ergonomics, the journal of the Ergonomics Society, published monthly by Taylor & Francis

Human Factors: The Journal of the Human Factors and Ergonomics Society, published by SAGE Publications

International Journal of Industrial Ergonomics, published monthly by Elsevier

Occupational Health Psychology

Journal of Occupational Health Psychology, published quarterly by the American Psychological Association

General News and Scientific Update Publication

BNA Occupational Safety & Health Reporter, published weekly by the Bureau of National Affairs

2

Occupational and Environmental Health Equity and Social Justice

Cora Roelofs, Sherry L. Baron, Sacoby Wilson, and Aaron Aber

CASE 1

A 21-year-old African-American man who had graduated from high school and completed the Job Corps federal job training program applied for dozens of jobs. When he was not hired, he wondered if racial discrimination was a factor. Unable to find steady work, he went to a temporary services agency and found a job at a rum factory. Excited, he called his mother to tell her the good news. He asked her to drive him to a store to buy the required uniform, including steel-toe boots, and to the factory for a 15-minute orientation before the 3 pm start of his first shift. He then took a photo of himself in his workclothes and orange safety vest and texted it to his fiancée. Less than 2 hours later, he was dead. He had been sent to clean out broken bottles that were clogging a machine that stacked boxes on a pallet. While he was out of sight, another worker started the machine, crushing him to death. When the Occupational Safety and Health Administration (OSHA) investigated the incident, the agency found that it was similar to many others: temporary workers with little or no safety training, but wanting to prove themselves to gain permanent employment, had been fatally injured during the first few days at a hazardous job. Neither the temporary agency nor the site employer took responsibility for safety.¹

CASE 2

Several physicians discovered that many children from a poor rural area in North Carolina near industrial hog operations were having diarrhea. Several of their parents were also having gastrointestinal symptoms, especially after heavy rains. They and other residents complained to the local health department about odors and rainwater runoff from the hog operations. The health department found high levels of *Escherichia coli* and fecal coliforms in residential well water—up to 1,000 times higher than maximum contaminant levels set by the Environmental Protection Agency (EPA). Using online mapping tools, some high school students found that the hog operations were near poor and African-American neighborhoods.

Health equity is a fundamental principle of social justice and human rights. According to the Centers for Disease Control and Prevention (CDC), health equity “is achieved when every person has the opportunity to ‘attain his or her full potential’ and no one is ‘disadvantaged from achieving this potential because of social position or other socially determined circumstances.’”²

Low-income people and people of color are more likely to encounter chemical, physical, and

biological hazards and psychosocial stressors in their communities and at work—an example of health *inequity*.³ Neighborhood environmental stressors include air pollution, water contamination, hazardous wastes, unhealthful land uses (such as for incinerators and landfills), and inadequate health-promoting facilities (such as parks and bicycle lanes). Disparities in work-related exposures arise from disproportionate employment in hazardous jobs—compounded by workplace discrimination, ineffective prevention and training, and restructuring of the workplace, creating less secure jobs.

OCCUPATIONAL HEALTH EQUITY

In 1911, a fire occurred in the Triangle Shirtwaist Factory in New York City, killing 145 of the 600 workers, who were mostly young immigrant women. Many of the exit doors had been locked by factory owners to prevent workers from stealing items. In Hamlet, North Carolina, 80 years later, 25 workers trapped behind locked fire doors were killed and 55 workers were injured in a fire at a poultry-processing plant; most of the workers were African Americans. Workers today have much in common with these workers: They experience hazardous working conditions. Many do not speak English. Many have limited education and limited job skills. Many belong to minority groups disparaged by others. And many are imperiled by inadequate government action to assure safe and healthful working conditions.⁴

Almost 17 million workers (16% of all private-sector workers) in 2010 were employed in hazardous jobs where work-related injuries and illnesses occur twice as often than in other (safer) jobs.⁵ Immigrant, minority, and low-wage workers with limited employment options are disproportionately employed in the most hazardous jobs. Understanding how and why these disparities exist provides insights for improving occupational health equity.

Changing Nature of Work

The U.S. poultry-processing industry today illustrates how industrial restructuring has contributed to occupational health inequity. Poultry

processing workers experience extremely high rates of injuries—close to 50% higher than all private-industry workers in 2015. These injuries include disabling repetitive strain injuries, such as carpal tunnel syndrome, and amputations. As consumer preference for chicken has increased, poultry plants have become larger and more mechanized, line speeds have increased, and work tasks no longer require skilled workers. Poultry processing jobs are now predominantly concentrated in five southern states because companies find “an ample supply of nonunion, lower-wage workers” who are willing to work in these unskilled jobs.⁶ Poultry processing workers are disproportionately African-American and Latino immigrants, reflecting both the historic concentration of African-American workers in the South and the increasing flow of Latino immigrant workers into southern states where they can find jobs. (See Figure 2-1.)

In North Carolina, Latino immigrant and African-American poultry-processing workers face more work hazards compared to other similar workers in their communities. Latino immigrant poultry workers report less opportunity to control how they do their work, experience more psychological demands, use more awkward postures and repetitive motions, and feel that management is not committed to safety, compared to other Latino immigrant manual-labor workers in their community.⁷ Similarly, African-American female poultry-processing workers in a different region of North Carolina are three times as likely to have a musculoskeletal disorder (MSD) and three times as likely to report diminished physical health-related quality of life, compared to other African-American female low-wage workers in their community. Despite their higher injury rates, these women also feel reluctant to report their injuries because, as one woman commented, “There are 300 people in line behind me for my job.”⁸

David Weil, former director of the Wage and Hours Division of the U.S. Department of Labor, describes the current workplace as “fissured”—with employers increasingly using contractors and subcontractors for hiring, evaluation, pay, supervision, training, and coordination of workers.⁹ As a result, job insecurity has increased,



Figure 2-1. Workers processing chickens on an assembly line. Minority workers and women are overrepresented in entry-level jobs like this one, in which safety and health hazards are prevalent. Twenty-five workers in a similar chicken-processing plant died in 1991, when few workers were able to escape a fire that swept through the plant because the employer had locked most of the exit doors. (Photograph by Earl Dotter.)

real wages and benefits have declined, and fewer workers are represented by labor unions. Although hard to estimate, as many as 18% of U.S. workers are employed in these nonstandard work arrangements and are called temporary, contract, contingent, and, more recently, “gig” or “app-based” workers.^{10,11}

By employing workers in nonstandard jobs, companies decrease labor costs, reduce employment during periods of low production, and avoid providing workers with benefits, such as health insurance and pensions.¹² These attributes that make temporary workers attractive to employers also often make temporary work more hazardous. Work-related injuries and illnesses among temporary workers are associated with increased workloads, longer working hours, decreased training, and breakdowns in workplace communication.^{10,13} Temporary workers also have less knowledge of their work environment, less job training, and difficulties raising concerns about working conditions and getting their views heard by management. While many workers face unsafe production pressures, temporary workers often feel pressure to “cut corners” in hopes of securing permanent employment.

Temporary work usually involves complex employment relationships between the temporary employment agency, the worksite supervisor, and the worker. Employers report confusion over who is responsible for health and safety—the temporary agency (which does not have control over worksite conditions) or the person who is directly supervising the worker at the workplace (but is not the worker’s legal employer). Recognizing this complexity, OSHA has recently issued guidance that clearly delineates shared and joint responsibility for health and safety between temporary agencies and host employers.¹⁴ For example, the staffing agency is required to purchase any required personal protective equipment (PPE), but the host employer is responsible for informing the agency about what PPE is required.

Informal workers (who comprise the *underground economy*) represent a category of temporary workers. In the United States, there are over 100,000 day laborers, each of whom waits every workday on a street corner or at a hiring center, seeking temporary employment in construction, landscaping, agriculture, cleaning, or moving and hauling.¹⁵ Like other

contingent workers, informal workers have high rates of work-related injuries. Immigrants who lack legal authority to work in the United States (*undocumented immigrants*) frequently work in informal employment arrangements in which they face hazardous conditions. Undocumented workers report less knowledge of their rights to a safe workplace and significant fear of employer retaliation if they were to report hazards.¹⁶

Workplace Injustice

CASE 3

In 1930, a subsidiary of a large corporation contracted with a construction firm to dig a 3-mile tunnel, the Gauley Bridge, through a stone mountain in West Virginia to divert the New River and build a hydroelectric energy plant. This 2-year project employed thousands of workers, at least 75% of whom were African Americans, in a county whose population was 85% Caucasian. Many of these African-American workers came from Alabama, Virginia, North Carolina, and South Carolina, where work was hard to find then (during the Great Depression) and to whom the hourly wage of \$0.30 to \$0.60 was acceptable.

The rock through which the workers drilled had some of the highest known content of crystalline silica. To complete the job quickly, the company chose to use minimal water to suppress dust levels. One year after the project began, the local newspaper published a story commenting on “the unusually large number of deaths among the colored laborers. The deaths total about 37 in the past two weeks.” Although the initial deaths were attributed to African-American workers’ poor nutritional habits and unusual susceptibility to pneumonia, it soon became clear that they were dying of acute silicosis. As many as 581 of the 922 African-American workers who worked in the tunnels for at least 2 months may have died.¹⁷ (See Chapter 22 for a discussion of silicosis.)

Although the blatant discrimination that is described in this case is far less common today, disparities persist. For example, in Michigan

between 1985 and 2010, the incidence rate of silicosis over age 40 among African-American men was 8.5 per 100,000, compared to 1.6 per 100,000 for white men.¹⁸

Workplace injustice, including abuse, mistreatment, discrimination, and harassment, is associated with mental and physical health problems.^{19–21} Workplace discrimination, based on race, gender, age, or sexual preference, occurs in many forms, including preferential hiring, firing, and job placement, as well as coworker and supervisor hostility. (See Chapter 14.) This discrimination is manifest in the wage and the unemployment gaps between African-American and white workers. Since 1976, the unemployment rate for blacks has consistently remained about twice that of whites, regardless of educational attainment. African-American households earn 40% less than white households. Black African Americans are only slightly less likely today to live in poverty than they were in 1976.²²

Racial and ethnic discrimination is prevalent in many workplaces in the United States.^{23,24} Experiencing racial insults, both at work and elsewhere, and unfair treatment at work have been associated with mental health disorders among workers and their families.^{25,26}

Beyond its psychological toll, workplace discrimination may lead to differential exposure to chemical and physical hazards at work. *Job-placement discrimination* can mean that less-favored workers are assigned to more hazardous work tasks. For example, a study of immigrant poultry workers found an association between retaliatory behavior by supervisors and a 10% to 30% increase in adverse health outcomes. Workers reported that native-born workers were given easier and cleaner jobs and that undocumented immigrants were more frequently asked to work unpaid overtime or, if they refused, were assigned unpleasant tasks.²⁷

Another form of discrimination is *workplace segregation*, in which one group of workers disproportionately works in certain jobs with a greater risk of psychosocial stress. African Americans, especially those in the middle class, who perceive that they are in a “black job” experience greater psychological distress.²⁸ African-American and white workers, who worked in jobs where more than 20% of the employees were African-American, reported poor or fair



Figure 2-2. Worker in a commercial laundry. (Photograph by Earl Dotter.)

overall health more often, even after adjusting for demographic factors, income, and education.²⁹ This segregation is most apparent in many lower-status jobs, where workers lack power and are disproportionately exposed to hazardous conditions.¹³ (See Figure 2-2.) For example, three of the six largest occupation groups—with more than 1 million workers each—that have the highest injury rates are disproportionately African-American and Hispanic; maids and housekeepers are predominantly female and disproportionately Hispanic; health aides are predominantly female and disproportionately African-American; and manual laborers are predominantly male and disproportionately African-American and Hispanic.³⁰

CASE 4

A young man, in search of a job, crossed the border from his native Mexico to the United States. He had a cousin living in Los Angeles, who told him that construction jobs were easy to obtain. Once he arrived, he found a job working as a sandblaster for a small construction company. The company did not ask for any official documents and paid him informally in cash (“under the table”). Although the sandblasting

created a lot of dust, his employer gave him no respiratory protection. To avoid breathing too much dust, he tied a bandana around his face, as farmworkers in his small home town in rural Mexico had done when they sprayed pesticides. He earned a good income and regularly sent money back to his family in Mexico. However, after a few years doing this job, he began to cough and wheeze. When he barely had enough energy to make it through the work-day, he saw a doctor who diagnosed him with advanced silicosis. Unable to work and without medical insurance or knowledge of workers’ compensation insurance, he returned to Mexico and died a few years later.

Many foreign-born immigrant workers (Figure 2-3) face challenges at work that negatively impact their health:

- They are often targets of racism and other forms of discrimination.³¹
- They are more likely to be employed in service, natural-resources, construction, maintenance, production, transportation, material-moving, and other high-risk occupations.
- Limited English-speaking ability, low job skills, and little education make many vulnerable to employers who exploit them.



Figure 2-3. Crab pickers working as “guest workers” in Maryland. (Photograph by Earl Dotter.)

- They are less likely to be informed about their rights to a safe workplace and less likely to be provided appropriate PPE.^{12,32}
- They are less likely to be aware of OSHA protections.
- They are more likely to work for employers who underreport injuries and illnesses.³³
- They are more likely to be targeted by Immigration and Customs Enforcement if they are injured on the job.³⁴

Approximately 11 million unauthorized immigrants reside in the United States, 8 million of whom are in the labor force. Unauthorized immigrants may be at high risk for work-related injuries and illnesses because their immigration status and their need for money drive them to take hazardous jobs. They are more likely to be employed as agricultural or construction laborers and less likely to report hazards.^{16,35,36}

CASE 5

The manager of a sausage factory reviewed the factory’s annual injury logs and noted that female employees were more likely to develop MSDs than men. He recalled reading in a trade magazine that women are more likely to develop carpal tunnel syndrome, and he

therefore attributed their relatively higher injury rate to biological factors. A union safety representative also reviewed these injury records and decided to investigate further. He inspected the sausage-finishing station, where several of the injuries had occurred, and observed women lifting 40-pound racks of sausages onto a shelf that was designed for much taller workers. After a short discussion, he learned that these women had previously worked in evening-shift jobs, which were less stressful ergonomically, but they had recently switched to day-shift jobs, in order to be home when their children returned from school. In order to prevent more injuries, the manager worked with the union safety representative and the workers to redesign the shelf to avoid lifting hazards.

This case illustrates how female workers may face discrimination at work. The design of a work station may be ergonomically optimal for the average male stature, but it may require significant reaching and awkward postures for short female workers, causing them to have more ergonomic stresses and increased risk of injury. In addition, female workers and their partners experience stress due to conflicts between work and family responsibilities. For low-wage female workers, many of whom are single mothers, the challenge of balancing their roles as wage earners and as mothers is often especially stressful.



Figure 2-4. Women coal miners. (Photograph by Earl Dotter.)

Women—and people who do not conform to typical gender norms—may be harassed or bullied with adverse effects on their mental and physical health and safety at work. Sexual harassment of women workers includes gender stereotyping, sexist jokes, and demeaning behavior. This and other forms of gender discrimination can lead to inequities at work:

- Women are overrepresented in service occupations, such as nursing assistants, that have high injury rates.
- In jobs where they are underrepresented, like construction and mining jobs (Figure 2-4), women may feel the need to prove themselves in ways that put them at increased risk of injury.³⁷
- Women are at higher risk than men to be exposed to violence at work.³⁸
- Women may suffer because male physical norms are the bases for exposure standards and PPE may not be available for women (or men) of small stature.^{37,39}

- Overall, women earn less than men. Among low-wage workers who are African-American or Hispanic, this income gap is even greater.⁴⁰

Inadequate Government Protection

Government regulations and social-safety-net programs have not reduced many of the inequities described previously. Many OSHA standards on specific workplace hazards have become outdated, and the number of OSHA inspectors is inadequate to enforce standards. (See Chapter 3.)

Some workers, including farm workers (Chapter 32A), domestic workers (such as house cleaners and home care workers), and, in many states, public employees, are often excluded from coverage by OSHA. The Fair Labor Standards Act of 1938 enabled the U.S. Department of Labor to establish regulations limiting work hours and prohibiting work after 7 PM on school nights for children under age 16 and regulations prohibiting children under age 18 (or under 16 in agricultural work) from performing certain tasks, such as operating power-driven wood-working equipment. However, these regulations are frequently violated.⁴¹

OSHA enforces regulations in part by conducting inspections in response to worker complaints. Nonunion workers, immigrant workers, and workers with limited English-language skills face barriers in making complaints or participating in inspections. When OSHA requests input on new regulations or strengthens existing ones, these workers are often not represented.

Low-income workers without health insurance who are injured at work often have to pay for their medical expenses. As one study found, Hispanic construction workers are half as likely as non-Hispanic white construction workers to be covered by workers' compensation for a work-related injury and four times more likely to pay out-of-pocket expenses—on average, almost \$2,000.⁴²

Low-wage workers also have less paid sick leave. In 2015, for workers whose wages were in the bottom quartile, only 41% had access to paid sick leave.⁴³ When, as a result, ill or injured workers come to work (instead of staying at home)—a situation known as *presenteeism*—they and their

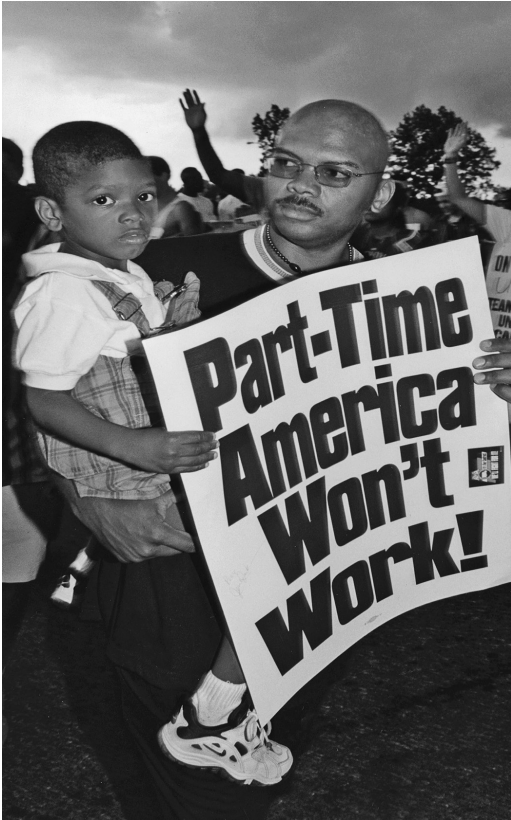


Figure 2-5. Part-time workers, like this man holding his son, often work for low wages and little or no benefits in precarious work situations. (Photograph by Earl Dotter.)

coworkers may suffer. Low-wage workers without paid sick leave are also less likely to take time off from work to care for themselves or sick family members.⁴⁴ When children with, for example, upper respiratory infections then go to school, they can spread these infections to other children. Without paid sick leave to care for an ill family member, a worker may be distracted and suffer a serious injury.⁴⁵ (See Figure 2-5.)

ENVIRONMENTAL HEALTH EQUITY

CASE 6

A father from a small community on the outskirts of a city testified in court about how, for the previous 15 years, a landfill near his

property had adversely affected his health, his family members' health, and the quality of life in his neighborhood. He had smelled odors from the landfill and, when the wind blew in his direction, he experienced headaches, a bad cough, and burning of his eyes, nose, and throat. He heard noise from trucks bringing garbage to the landfill and saw rats in the woods near the landfill and buzzards flying overhead. He did not understand why more was not being done to monitor the landfill. His family members and many neighbors were sick. For 15 years, they complained to the local health department and the state environmental protection agency. They learned from the EPA that tests of local well water 20 years before indicated that the groundwater was not safe for consumption; it contained high levels of metals and other contaminants that can cause cancer, birth defects, and neurological disorders. The EPA recommended that anyone who lived within 2 miles of the landfill not drink well water and use the closest publicly-regulated drinking water system or drink only bottled water.

During testimony from town officials, the man learned that city officials knew about this contamination long before and had provided alternate water sources to well-to-do people living near the landfill but not to poor people, immigrants, or people of color. When the judge questioned town officials about their actions, they stated that they disseminated public notices and held stakeholder meetings but no one from the man's neighborhood had responded.

This case is not unique. For over 20 years, researchers have demonstrated that many low-income populations, communities of color, immigrant communities, and other underserved populations and marginalized and disenfranchised groups live in neighborhoods that experience disproportionate risks from exposure to environmental hazards. These hazards include many noxious land uses, such as landfills, incinerators, publicly owned treatment works (such as sewer and water treatment plants), industrial animal operations, hazardous waste sites, chemical factories, power plants, heavily trafficked roadways, and other locally unwanted land uses.^{46–54} The cumulative impact of environmental injustice, due to the spatial concentration of

environmental hazards, factories, and noxious land uses, leads to increases in adverse health outcomes and community stress as well as lower quality of life and community sustainability. (See Chapters 15, 16, and 18.)

In the 1980s, the Environmental Justice Movement arose to address the disproportionate burden of environmental exposures on low-income and minority communities.^{46,47} It raised awareness of the many environmental and health issues that they faced and asked the federal government to respond. Two groundbreaking studies provided the initial evidence that supported claims of grassroots activists who had been fighting against environmental injustice in many places across the United States.

The first study, by the General Accounting Office in 1983, *Siting of Hazardous Waste Landfills and Their Correlation with Racial and Economic Status of Surrounding Communities*, examined the distribution of landfills in EPA Region IV (eight southeastern states); it found that (a) most residents in 75% of communities containing large hazardous waste landfills were African-American and (b) African Americans were overrepresented in communities with waste sites.⁵⁵

The second study, by the Commission for Racial Justice of the United Church of Christ in 1987, *Toxic Waste and Race in America*, demonstrated that (a) in ZIP codes without a toxic facility, less than 12% of the residents were persons of color; (b) in those with only one toxic facility, 24% of the residents were persons of color; and (c) in those with multiple toxic facilities or one of the five largest landfills, 38% of residents were persons of color.⁵⁶ The study found that 60% of African-Americans and Hispanics resided in communities with toxic waste sites.

The *Toxic Wastes and Race at Twenty* report, a follow-up to the 1987 study that was released in 2007, provided additional evidence about the disproportionate burden on disadvantaged populations of environmental hazards, industrial facilities, and unhealthy land uses.⁵² The report demonstrated that, nationally, people of color are approximately three times more likely to live in neighborhoods that host a commercial hazardous waste facility than whites. The study found that (a) more African Americans, Hispanics, and Asians reside in neighborhoods

that “host” toxic facilities than in “non-host” neighborhoods and (b) in metropolitan areas, more poor people live in host neighborhoods than non-host neighborhoods.

There is now a large body of literature on environmental justice, which has documented the disproportionate burden on poor populations, people of color, and other disadvantaged groups of environmental hazards, including unhealthy land uses (such as hazardous waste sites and landfills), refineries and petrochemical plants, other industrial facilities, and major highways.^{46,47,49}

Environmental Injustice

CASE 7

At a community meeting in a poor segregated neighborhood, its primarily Latino, African-American, and Asian residents discussed government plans to build another highway in the neighborhood. The neighborhood already had much motor-vehicle traffic and associated air pollution, causing asthma and other respiratory problems for many residents. During summers, many “ozone-alert” days made children and elderly residents stay inside, and heat waves caused many hospitalizations for heat stroke and other disorders. Residents complained of diesel smoke from trucks that drove through the neighborhood and transit and school buses that idled throughout the day.

A Department of Transportation official at the meeting stated that an environmental impact assessment projected that the planned highway would not increase air pollution. Town officials stated that the new highway could help promote economic development and attract new industries, businesses, and consumer traffic. A local physician reported that many of his young patients had asthma and many of his adult patients, especially those who lived near bus stops and highway exit ramps, were experiencing respiratory and cardiovascular problems. Some residents, who lived near an incinerator that released airborne pollutants, observed that the building of highways in the neighborhood had been accompanied by the construction of polluting factories.

Asthma, a prime example of health disparities resulting from environmental injustice,⁴⁹ is more prevalent among people of color than white people. (See Chapter 22.) CDC has documented the following disparities in asthma in the United States:⁵⁷

- In 2014, the asthma prevalence rate for Puerto Ricans (16.5%) was more than twice the rate for all Hispanics (6.7%) and significantly higher than the rate for whites (7.6%) and African Americans (9.9%).
- The asthma prevalence rates for Hispanic children (8.5%) and African-American children (9.9%) were higher than the rate for white children (7.6%). The rate for Puerto Rican children (23.5%) was significantly higher than for any other racial/ethnic group.
- In 2010, the rate of hospital inpatient discharges for asthma was 29.9 per 10,000 for African Americans and 8.7 per 10,000 for whites.
- In 2014, the asthma mortality rate for African Americans was 25.4 per million, compared to the rates for whites (8.8 per million) and Hispanics (7.7 per million).

Multiple factors likely account for higher rates of asthma among people color:

- Residence in areas with high exposure to fine particulate matter (PM_{2.5})
- A high burden of social stressors, including unstable employment and community violence⁵⁸
- Limited access to quality medical care.

Studies have demonstrated the relationship between environmental hazards and adverse pregnancy outcomes as well as disorders of children. For example, residential proximity to environmental hazards increases the risks for preterm birth, low birthweight, and birth defects, as well as childhood cancer and autism.^{59,60}

Residential Segregation

Residential segregation leads to disproportionate exposure to environmental risk factors—physical, social, and economic—that adversely

affect health and lead to health disparities in both urban and rural areas.^{46–49} In many urban areas, social, economic, and political forces along with historical patterns of community development, disinvestment, industrialization, and zoning and planning (including for highway development and expansion) have segregated populations of color in impoverished communities that have few resources and increased environmental risks.^{46,47} *Redlining* (a discriminatory practice by which banks and insurance companies refuse or limit loans, mortgages, or insurance within specific geographic areas, especially inner-city neighborhoods) and other forms of institutional discrimination have also contributed to segregation of disadvantaged populations.^{48,50,51} In these communities, relatively few municipal services are available, infrastructure has deteriorated, and the physical and natural environments have been eroded.⁵⁸ Many segregated populations are exposed to high levels of *criteria air pollutants*, such as carbon monoxide, particulate matter (PM), sulfur dioxide, and oxides of nitrogen, released from vehicles and factories in or near these neighborhoods.⁴⁹ (See Chapter 15.) Exposure to these pollutants can cause lung cancer or nonmalignant respiratory disorders, such as asthma.^{46,47,49} For example, studies in metropolitan areas with black–white segregation have shown that African Americans are exposed to higher levels of sulfur dioxide, PM, and ozone.^{2,47} In addition, segregation is associated with (a) greater exposure of populations of color to hazardous air pollutants and (b) increased risk of cancer, even after controlling for socioeconomic status.

Segregated communities are characterized by concentrated poverty, limited economic infrastructure, and low-quality social services and medical care. These factors act synergistically to raise levels of stress, increase vulnerability, and limit capacity of burdened populations to overcome disease and increase health status.^{46–49}

Community Planning and Development

Many factors have contributed to inequitable development in urban, suburban, and rural areas in the United States, including suburbanization (population movement from within cities

to the rural-urban fringe, which leads to urban sprawl), discriminatory housing policies, segregation, massive highway construction, deindustrialization, and poor zoning and planning.^{48,50} As a result, many areas have been divided by race, ethnicity, and socioeconomic status, creating environmental injustice. The segregation and spatial variation in planning and development in communities with different racial, ethnic, and socioeconomic composition have arisen from conditions and policies in different time periods. These conditions and policies have included *Jim Crow policies* in the South—state and local laws enacted between 1876 and 1965 that mandated racial segregation in all public facilities with a supposedly “separate, but equal” status for African Americans. They limited access for non-whites to low-interest home loans and they enabled exclusionary zoning, racial covenants, and redlining.⁵⁰ The uneven nature of community planning, zoning, and development has led to *fragmentation* (the division of metropolitan areas into multiple smaller municipal districts); *gentrification* (the restoration of run-down urban areas by the middle class, resulting in the displacement of low-income residents); and sprawl and the spatial concentration of environmental hazards and unhealthy land uses in communities affected by environmental injustice. Spatial fragmentation and gentrification have limited sustainable economic development, which, in turn, has adversely affected the quality of schools, housing, transportation, civic engagement, and social climate. (See Chapter 34.)

Although zoning and planning are sometimes perceived as objective processes, they actually are highly political, class-conscious practices. Early in the 20th century, zoning became widespread in the United States because it effectively regulated land use, making it difficult or impossible for less affluent people to cross community boundaries. For example, in New York City, zoning was a social and political process, in which much of Bronx, Brooklyn, and Queens was zoned as unrestricted, which promoted—for economic reasons—development of hazardous industrial facilities in poor and working-class areas.⁶¹ Zoning and race were closely related. For example, the Bronx had the highest concentration of poor and minority residents as well as large increases in areas zoned for manufacturing,

which exposed nearby residents to disproportionate amounts of environmental toxicants. In contrast, more affluent Manhattan had the greatest decrease in manufacturing. This zoning pattern also occurred in Chicago, Atlanta, Detroit, Los Angeles, and other U.S. cities.

New movements in planning and community development, including *new urbanism* (an urban-design movement that focuses on the development of walkable communities) and *smart growth* (an urban planning approach that focuses on concentrated growth; mixed-use development; and compact, walkable, pedestrian-friendly, transit-oriented neighborhoods to reduce sprawl and improve neighborhood sustainability) have been adopted by planners, local government officials, architects, and environmental organizations to improve health, sustainability, and quality of life in neighborhoods, towns, and cities. (See Chapter 34.) These movements have not gone far enough in addressing environmental injustice and social inequalities, and they may lead to more segregation, gentrification, and uneven planning, zoning, and development.^{48,50} For example, the adverse social, economic, environmental, and health impacts of urban revitalization on disadvantaged populations are evident in the destruction of core urban neighborhoods in large cities and displacement of underserved and disadvantaged residents. Therefore, economically advantaged populations, who benefitted disproportionately from suburbanization, may benefit disproportionately from new revitalization efforts, while historically disadvantaged populations may be adversely affected.⁵⁰ Without equity-based policies, the elimination of environmental injustice and health disparities in disadvantaged communities through new forms of planning and community development may not occur.

Inequitable zoning, planning, and community development contribute to lack of access to basic amenities, such as sewer and water infrastructure, good housing, parks, green space, recreational facilities, and pedestrian-friendly residential environments in rural areas and small towns.^{48,50,51,62} The problems of unjust transportation planning and urban sprawl have been studied in Atlanta,^{63,64} revealing how transportation inequities can contribute to environmental injustice and public health problems.

There is also a high concentration of *pathogenic infrastructure*, such as fast-food restaurants, liquor stores, and check-cashing facilities, in poor neighborhoods and communities of color in southern states and large cities.^{65,66}

The Built Environment

CASE 8

A mother of three children attended a parent-teacher association meeting at a local junior high school to find out more information about its new garden. Her children had come home after school a few weeks before excited about a new school program in which students would have physical activity and eat organic produce from the school's garden or the local farmers' market. At the meeting, the mother was shocked to learn that the program was established because of high rates of obesity and diabetes among students. Two of her children were overweight and one had been diagnosed with diabetes at age 10. A local professor stated that her neighborhood was a *food desert*, with no supermarkets or grocery stores and fresh fruits and vegetables available only at a gas station's convenience store. The professor stated that the neighborhood had poor access to mass transit, preventing residents from having access to supermarkets in other locations, but an excessive number of fast-food restaurants. The mother recalled how often she bought her children hamburgers and French fries from a nearby fast-food restaurant.

In response to the professor's assertions, a community leader stated that the neighborhood was not a food desert, but rather that it had been impacted by environmental injustice and *food apartheid*. She said she had been working for 20 years to try to bring about better community development and more supermarkets, but that politicians countered that the neighborhood could not support a supermarket or even a medium-sized grocery store. However, she noted that some progress had been made in turning empty lots into community gardens and cleaning up many of the parks.

which contributes to health inequalities, is a major concern for communities affected by environmental injustice.⁴⁸ For example, low-income neighborhoods, urban neighborhoods, and neighborhoods that are predominantly African-American have less access to supermarkets than wealthier neighborhoods, suburban neighborhoods, and those that are predominantly white.⁶⁵ The presence of supermarkets is associated with better diets and lower rates of overweight, obesity, and hypertension. In many segregated and fragmented areas, the lack of health-promoting food resources creates a food desert, which is made worse by limited transportation opportunities for local residents. Many of these poor segregated communities do not have access to personal vehicles or reliable public transit, which limits access to distant supermarkets. These environmental restraints and overabundance of food outlets in convenience stores and gas stations adversely affect diet, lifestyle, and risks for obesity, cardiovascular disease, and diabetes.^{48,50} (See Chapter 34.)

Poor neighborhoods and communities of color impacted by environmental injustice are also less likely to have access to opportunities for physical activity, including green space, parks, and recreational facilities.⁶⁶ Even when there are facilities, other factors, such as poor neighborhood aesthetics and safety, limit physical activity in these neighborhoods. Limited access to medical care and lower quality of care adversely affect health and increase disparities in disadvantaged neighborhoods.⁵⁸ Being both disadvantaged and medically underserved means that residents are likely to have higher rates of chronic illnesses, drug abuse, mental health problems, unhealthy behaviors, lower childhood immunization rates, and more hospitalizations for preventable diseases than people living elsewhere. In addition, poor and minority communities impacted by environmental injustice are overburdened by health-restricting infrastructure with *environmental pathogens*.⁴⁸ Poor and minority communities have more access to fast-food restaurants and stores selling alcohol and tobacco and are more frequently targeted by advertisements for fast food, alcohol, and tobacco.

The local environment in disadvantaged communities, especially those affected by

The lack of positive and health-promoting features in the built and social environments,

environmental injustice, has adverse impacts on quality of life, lifestyles, and behaviors. Taken together, the differential burden of increased exposure to environmental pathogens and decreased access to health-promoting resources have important implications for promoting public health and addressing environmental health disparities in these communities. The presence of environmental pathogens in a community can limit the ability of agencies to promote public health because these pathogens may create community stress or promote negative health behaviors. In addition, these pathogens may act as sources of pollution. And, because these communities have little or no access to health-promoting infrastructure, such as parks, open space, and healthcare facilities, policies to reduce environmental health disparities may be unsuccessful.

APPROACHES TO DECREASING OCCUPATIONAL AND ENVIRONMENTAL HEALTH INEQUITIES

Occupational and environmental health inequities are difficult to reduce, given the complex social, political, and economic forces that have created and sustained them. Successful interventions often require developing partnerships with community-based and other organizations that develop knowledge and insights about the problems and commitment to creating sustainable change.

Labor Unions

Labor unions have been important partners for occupational health practitioners and researchers in improving workplace safety and health. Many unions have health and safety staff who help members understand the hazards they are facing and work with managers to improve conditions. Unions help members engage in employer health and safety programs through joint labor-management health and safety committees and provide safety training through jointly funded programs. Occupational health practitioners have assisted labor unions in training workers to be knowledgeable and active members of these committees, such through the Worker Occupational Safety and Health Training and

Education Program, funded by the California workers' compensation program. Unions have helped establish federal funding for the medical surveillance and compensation of workers who have experienced extreme work-related exposures. The Black Lung Compensation Program for disabled miners, the Energy Employees Occupational Illness Compensation Program, and the 9/11 World Trade Center Worker Health Program are examples of such surveillance and compensation programs. Unions also partner with researchers to investigate problems. A study showing that hotel housekeeping workers had high rates of back injuries due to heavy lifting, helped the workers' union negotiate workload reductions, which reduced the occurrence of back injuries.⁶⁷

Worker Centers

The growing number of immigrant workers and their advocates, including faith-based organizations, have established community-based worker centers. Although these centers are not recognized as workers' representatives for the purposes of collective bargaining, as labor unions are, they organize and advocate for better working conditions. For example, the CLEAN Carwash Campaign has integrated occupational and environmental health issues into its campaign to combat wage theft and raise the minimum wage among the 10,000 mostly immigrant "carwashers" in Los Angeles.⁶⁸ As another example, student interns in the national Occupational Health Internship Program worked with worker centers to interview workers, research chemical hazards, and support an outreach program to prevent heat-related illnesses and inform outdoor workers of their rights under state law to water, shade, and rest breaks.⁶⁹ In some cases, worker centers have formed national alliances to advocate for policy changes at the state and federal level. One such alliance is the National Domestic Workers Alliance, which has advocated for state laws supporting the rights of domestic workers. Several states have enacted "bills of rights" for domestic workers, guaranteeing them written contracts, workers' compensation coverage, maternity leave, and/or other rights, such as adequate time and conditions for sleeping.^{70,71}

COSH Groups

State and regional coalitions for occupational safety and health (COSH groups) bring together academics, unions, worker centers, and public health professionals to provide technical assistance to workers; to advocate at the state level for better protections; and to honor workers who have died on the job by organizing Workers Memorial Day events. The Teens Lead @ Work project of the Massachusetts Coalition for Occupational Safety and Health, in collaboration with the Massachusetts Department of Public Health, trains teens to do peer-to-peer health and safety training. Working teens organized through Teens Lead @ Work successfully advocated for stronger child labor laws to enable the state attorney general to fine employers who place teen workers at risk.

Public Health Association

The Occupational Health and Safety (OHS) Section and the Environment Section of the American Public Health Association address equity and social justice issues at its annual meeting, through policy development, recognition of outstanding contributions to advancing health equity, and student mentoring. The OHS Section developed a curriculum for teaching about occupational health equity in colleges and schools of public health, which has been posted online.⁷²

Community Empowerment Projects

An effective approach to increase health equity is *community-based participatory research* (CBPR), in which community groups, with their grassroots activism, resources, and local knowledge and expertise, collaborate with scientists to address local issues.^{73–77} This approach allows for the research process to be action-oriented, thereby increasing and sustaining the community's capacity to address health equity issues as well as increasing civic engagement by minority and low-income stakeholders.^{76,77} By creating a shared responsibility for research, this approach brings equality to the relationships between local and scientific experts and ensures that

community-driven research is locally relevant. Many CBPR projects also emphasize the role and participation of community youth, which creates an intergenerational pipeline of community leaders knowledgeable about local health and social justice issues.

El Puente and the Watchperson Project, two community-based organizations in Brooklyn, have engaged in community-driven research to address asthma and risks from subsistence fish diets. Each organization has built its capacity to collect locally relevant data, working in partnership with EPA scientists, and to receive training in data-collection methods. Similarly, the West End Revitalization Association, a community-based environmental justice organization in Mebane, North Carolina, has developed a community–university partnership with researchers and students, primarily from the University of North Carolina at Chapel Hill. Community participants have received training on data-collection methods to build community capacity to address health disparities related to sewer and water infrastructure.^{76,77}

REFERENCES

1. *A day's work* [Documentary film]. David M. Garcia and Dave DeSario, Executive Producers, 2015.
2. Centers for Disease Control and Prevention. CDC's Healthy Communities Program: Attaining health equity. Available at: <https://www.cdc.gov/nccdphp/dch/programs/healthycommunitiesprogram/overview/healthequity.htm>. Accessed June 8, 2017.
3. Adler N, Steward J, Cohen S, et al. Reaching for a healthier life: Facts on socioeconomic status and health in the U.S. The John D. and Catherine T. MacArthur Foundation Research Network on Socioeconomic Status and Health, 2007. Available at: http://www.macses.ucsf.edu/downloads/reaching_for_a_healthier_life.pdf. Accessed February 20, 2017.
4. Campbell R, Levenstein C. Fire and worker health and safety: An introduction to the special issue. *New Solutions* 2015; 24: 457–468.
5. Steege AL, Baron SL, Marsh SM, et al. Examining occupational health and safety disparities using national data: A cause for continuing concern. *American Journal of Industrial Medicine* 2014; 57: 527–538.

6. The Pew Charitable Trusts. The business of broilers: The high cost of putting a chicken on every grill, December 20, 2013. Available at: <http://www.pewtrusts.org/en/research-and-analysis/reports/2013/12/20/the-business-of-broilers-hidden-costs-of-putting-a-chicken-on-every-grill>. Accessed February 20, 2017.
7. Cartwright MS, Walker FO, Newman JC, et al. One-year incidence of carpal tunnel syndrome in Latino poultry processing workers and other Latino manual workers. *American Journal of Industrial Medicine* 2014; 57: 362–369.
8. Lipscomb H, Kucera K, Epling C, Dement J. Upper extremity musculoskeletal symptoms and disorders among a cohort of women employed in poultry processing. *American Journal of Industrial Medicine* 2008; 51: 24–36.
9. Weil D. *Fissured workplace: Why work became so bad for so many and what can be done to improve it*. Cambridge, MA: Harvard University Press, 2017.
10. Howard J. Nonstandard work arrangements and worker health and safety. *American Journal of Industrial Medicine* 2017; 60: 1–10.
11. U.S. Government Accountability Office. Contingent workforce: Size, characteristics, earnings, and benefits, April 20, 2015. Available at: <http://www.gao.gov/assets/670/669766.pdf>. Accessed February 20, 2017.
12. Virtanen M, Kivimäki M, Joensuu M, et al. Temporary employment and health: A review. *International Journal of Epidemiology* 2005; 34: 610–622.
13. Landsbergis PA, Grzywacz JG, LaMontagne AD. Work organization, job insecurity, and occupational health disparities. *American Journal of Industrial Medicine* 2014; 57: 495–515.
14. Occupational Safety and Health Administration. Recommended practices: Protecting temporary workers, 2014. Available at: <https://www.cdc.gov/niosh/docs/2014-139/pdfs/2014-139.pdf>. Accessed February 20, 2017.
15. Seixas NS, Blecker H, Camp J, Neitzel R. Occupational health and safety experience of day laborers in Seattle, WA. *American Journal of Industrial Medicine* 2008; 51: 399–406.
16. Flynn MA, Eggerth DE, Jacobson CJ. Undocumented status as a social determinant of occupational safety and health: The workers' perspective. *American Journal of Industrial Medicine* 2015; 58: 1127–1137.
17. Cherniack, M. *The Hawk's Nest Incident: America's worst industrial disaster*. New Haven, CT: Yale University Press, 1986.
18. Stanbury M, Rosenman KD. Occupational health disparities: A state public health-based approach. *American Journal of Industrial Medicine* 2014; 57: 596–604.
19. Okechukwu CA, Souza K, Davis KD, de Castro AB. Discrimination, harassment, abuse, and bullying in the workplace: Contribution of workplace injustice to occupational health disparities. *American Journal of Industrial Medicine* 2014; 57: 573–586.
20. Fleming PJ, Villa-Torres L, Taboada A, et al. Marginalisation, discrimination and the health of Latino immigrant day labourers in a central North Carolina community. *Health and Social Care in the Community* 2017; 25: 527–537.
21. Slopen N, Williams DR. Discrimination, other psychosocial stressors, and self-reported sleep duration and difficulties. *Sleep* 2014; 37: 147–156.
22. National Urban League. 2016 state of black America: Locked out: Education, jobs, and justice. Available at: <http://soba.iamempowered.com/>. Accessed February 20, 2017.
23. Byrd DR. Race/ethnicity and self-reported levels of discrimination and psychological distress, California, 2005. *Preventing Chronic Disease* 2012; 9: 120042. doi:<http://dx.doi.org/10.5888/pcd9.120042>.
24. Chavez LJ, Ornelas IJ, Lyles CR, Williams EC. Racial/ethnic workplace discrimination: Association with tobacco and alcohol use. *American Journal of Preventive Medicine* 2015; 48: 42–49.
25. Williams DR, Mohammed SA. Discrimination and racial disparities in health: Evidence and needed research. *Journal of Behavioral Medicine* 2009; 32: 20–47.
26. Krieger N. Discrimination and health inequities. *International Journal of Health Services: Planning, Administration, Evaluation* 2014; 44: 643–710.
27. Marín AJ, Grzywacz JG, Arcury TA, et al. Evidence of organizational injustice in poultry processing plants: Possible effects on occupational health and safety among Latino workers in North Carolina. *American Journal of Industrial Medicine* 2009; 52: 37–48.
28. Forman TA. The social psychological costs of racial segmentation in the workplace: A study of African Americans' well-being. *Journal of Health and Social Behavior* 2003; 44: 332–352.
29. Chung-Bridges K, Muntaner C, Fleming LE, et al. Occupational segregation as a determinant of US worker health. *American Journal of Industrial Medicine* 2008; 51: 555–567.

30. Baron S. Nonfatal work-related injuries and illnesses—United States, 2010. *Morbidity and Mortality Weekly Report* 2013; 62: 35–40.
31. Roelofs C, Sprague-Martinez L, Brunette M, Azaroff L. A qualitative investigation of Hispanic construction worker perspectives on factors impacting worksite safety and risk. *Environmental Health* 2011; 10: 84.
32. Cummings KJ, Kreiss K. Contingent workers and contingent health: Risks of a modern economy. *JAMA* 2008; 299: 448–450.
33. Committee on Education and Labor. Hidden Tragedy: Underreporting of workplace injuries and illnesses. 2008. Available at: <https://www.bls.gov/iif/laborcommreport061908.pdf>. Accessed February 20, 2017.
34. Grabell M, Berkes H. They got hurt at work. Then they got deported. ProPublica and National Public Radio. August 16, 2017. Available at: <https://www.propublica.org/article/they-got-hurt-at-work-then-they-got-deported>. Accessed August 25, 2017.
35. AFL-CIO. Immigrant workers at risk: The urgent need for improved workplace safety and health policies and programs. 2005. Available at: <http://www.coshnetwork.org/sites/default/files/Immigrants%20at%20Risk%20AFL%20CIO.pdf>. Accessed February 20, 2017.
36. Trujillo-Pagán N. Hazardous constructions: Mexican immigrant masculinity and the rebuilding of New Orleans. In: C Johnson (ed.). *The neoliberal deluge: Hurricane Katrina, late capitalism, and the remaking of New Orleans*. Minneapolis, MN: University of Minnesota Press, 2011.
37. Goldenhar LM, Sweeney MH. Tradeswomen's perspectives on occupational health and safety: A qualitative investigation. *American Journal of Industrial Medicine* 1996; 29: 516–520.
38. Bureau of Labor Statistics. Nonfatal occupational injuries and illnesses requiring days away from work, 2015. Available at: <https://www.bls.gov/news.release/osh2.nr0.htm>. Accessed February 12, 2017.
39. Onyebeke LC, Papazaharias DM, Freund A, et al. Access to properly fitting personal protective equipment for female construction workers. *American Journal of Industrial Medicine* 2016; 59: 1032–1040.
40. Platt J, Prins S, Bates L, Keyes K. Unequal depression for equal work? How the wage gap explains gendered disparities in mood disorders. *Social Science & Medicine* 2016; 149: 1–8.
41. Runyan CW, Schulman M, Dal Santo J, et al. Work-related hazards and workplace safety of U.S. adolescents employed in the retail and service sectors. *Pediatrics* 2007; 119: 526–534.
42. Dong X, Ringen K, Men Y, Fujimoto A. Medical costs and sources of payment for work-related injuries among Hispanic construction workers. *Journal of Occupational and Environmental Medicine* 2007; 49: 1367–1375.
43. Bureau of Labor Statistics. Employee benefits in the United States—March 2016. Available at: <https://www.bls.gov/news.release/pdf/ebs2.pdf>. Accessed February 20, 2017.
44. Scherzer T, Rugulies R, Krause N. Work-related pain and injury and barriers to workers' compensation among Las Vegas hotel room cleaners. *American Journal of Public Health* 2005; 95: 483–488.
45. Siqueira CE, Gaydos M, Monforton C, et al. Effects of social, economic, and labor policies on occupational health disparities. *American Journal of Industrial Medicine* 2014; 57: 557–572.
46. Morello-Frosch R, Lopez R. The riskscape and the color line: Examining the role of segregation in environmental health disparities. *Environmental Research* 2006; 102: 181–196.
47. Morello-Frosch R, Jesdale B. Separate and unequal: Residential segregation and estimated cancer risks associated with ambient air toxics in U.S. metropolitan areas. *Environmental Health Perspectives* 2006; 114: 386–393.
48. Wilson SM. An ecologic framework to address environmental justice and community health issues. *Environmental Justice* 2009; 2: 15–24.
49. Gee GC, Payne-Sturges D. Environmental health disparities: A framework integrating psychosocial and environmental concepts. *Environmental Health Perspectives* 2004; 112: 1645–1653.
50. Wilson SM, Hutson M, Mujahid M. How planning and zoning contribute to inequitable development, neighborhood health, and environmental injustice. *Environmental Justice* 2008; 1: 211–216.
51. Wilson SM, Heaney CD, Cooper J, Wilson OR. Built environment issues in unserved and underserved African-American neighborhoods in North Carolina. *Environmental Justice* 2008; 1: 63–72.
52. Bullard RD, Mohai P, Saha R, Wright B. Toxic wastes and race at twenty, 1987–2007: A report prepared for the United Church of Christ Justice & Witness Ministries. 2007. Available at: <https://www.nrdc.org/sites/default/files/>

- toxic-wastes-and-race-at-twenty-1987-2007.pdf. Accessed February 20, 2017.
53. Bullard RD. Unequal protection: Environmental justice and communities of color. San Francisco: Sierra Club Books, 1994.
 54. Bryant B (ed.). Environmental justice: Issues, policies and solutions. Washington, DC: Island Press, 1985.
 55. U.S. General Accounting Office. Siting of hazardous waste landfills and their correlation with racial and economic status of surrounding communities. 1983. Available at: <http://archive.gao.gov/d48t13/121648.pdf>. Accessed February 20, 2017.
 56. Commission for Racial Justice, Union Church of Christ. Toxic wastes and race in the United States: A national report on the racial and socioeconomic characteristics of communities with hazardous waste sites. 1987. Available at: <https://www.nrc.gov/docs/ML1310/ML13109A339.pdf>. Accessed February 20, 2017.
 57. Centers for Disease Control and Prevention. Most recent asthma data. Available at: https://www.cdc.gov/asthma/most_recent_data.htm. Accessed February 20, 2017.
 58. Williams DR, Collins C. Racial residential segregation: A fundamental cause of racial disparities in health. *Public Health Reports* 2001; 404–416.
 59. Ritz B, Wilhelm M, Hoggatt KJ, Ghosh JK. Ambient air pollution and preterm birth in the environment and pregnancy outcomes study at the University of California, Los Angeles. *American Journal of Epidemiology* 2007; 166: 1045–1052.
 60. Ritz B, Yu F, Frui, S. Ambient air pollution and risk of birth defects in Southern California. *American Journal of Epidemiology* 2002; 155: 17–25.
 61. Sze J. Noxious New York: The racial politics of urban health and environmental justice. Cambridge, MA: MIT Press, 2007.
 62. Lindsey G, Maraj M, Kuan S. Access, equity and urban greenways: An exploratory investigation. *Professional Geographer* 2001; 53: 332–346.
 63. Bullard RD. Growing smarter: Achieving livable communities, environmental justice, and regional equity. Cambridge, MA: MIT Press, 2007.
 64. Houston D, Wu J, Ong P, Winer A. Structural disparities of urban traffic in southern California: Implications for vehicle-related air pollution exposure in minority and high poverty neighborhoods. *Urban Affairs Quarterly* 2004; 26: 565–592.
 65. Morland K, Wing S, Diez Roux A. Neighborhood characteristics associated with the location of food stores and food service places. *American Journal of Preventive Medicine* 2002; 22: 23–29.
 66. Taylor WC, Hepworth JT, Lees E. Obesity, physical activity, and the environment: Is there a legal basis for environmental injustices? *Environmental Justice* 2008; 1: 45–48.
 67. Lee PT, Krause N. The impact of a worker health study on working conditions. *Journal of Public Health Policy* 2002; 23: 268–285.
 68. UCLA Labor Center. CLEAN Carwash Campaign. Available at: <http://www.labor.ucla.edu/what-we-do/labor-studies/research-tools/campaigns-and-research/clean-carwash-campaign/>. Accessed February 20, 2017.
 69. Delp L, Riley K, Jacobs S, et al. Shaping the future: Ten years of the occupational health internship program. *New Solutions* 2013; 23: 253–281.
 70. Gaydos M, Hoover C, Lynch JE, et al. A health impact assessment of California Assembly Bill 889: The California Domestic Work Employee Equality, Fairness, and Dignity Act of 2011. May 2011. Available at: http://www.pewtrusts.org/~media/assets/2011/05/01/health_impact_assessment_ab_8891.pdf. Accessed February 20, 2017.
 71. National Domestic Workers Alliance. Available at: <https://www.domesticworkers.org/home>. Accessed February 13, 2017.
 72. UCLA Labor Occupational Safety and Health Program. Work & health equity curriculum. Available at: <http://losh.ucla.edu/resources-2/work-health-equity-module/>. Accessed February 13, 2017.
 73. Israel BA, Eng E, Schulz AJ, et al (eds.). *Methods in community-based participatory research*. San Francisco: Jossey-Bass, 2005.
 74. O’Fallon LR, Dearry A. Community-based participatory research as a tool to advance environmental health sciences. *Environmental Health Perspectives* 2002; 110: 155–159.
 75. Corburn J. *Street science: Community knowledge and environmental health justice*. Cambridge, MA: MIT Press, 2005.
 76. Heaney CD, Wilson SM, Wilson OR. The West End Revitalization Association’s community-owned and managed research model: Development, implementation, and action. *Progress in Community Health Partnerships* 2007; 1: 339–349.
 77. Wilson SM, Wilson OR, Heaney CD, Cooper C. Use of EPA collaborative problem-solving

model to obtain environmental justice in North Carolina. *Progress in Community Health Partnerships* 2007; 1: 327–338.

FURTHER READING

- UCLA Labor Occupational Health Program. Work & health equity curriculum. Available at: <http://losh.ucla.edu/resources-2/work-health-equity-module/>. Accessed February 20, 2017.
Useful materials for teaching undergraduates and graduate students about occupational health equity.
- Michaels D. Adding inequality to injury: The costs of failing to protect workers on the job. U.S. Occupational Safety and Health Administration, 2015. Available at: <https://www.dol.gov/osha/report/20150304-inequality.pdf>. Accessed February 20, 2017.
A critically important report by the director of OSHA at the time.
- Special Issue: Achieving health equity in the workplace. *American Journal of Industrial Medicine* 2014; 57: 493–614.
This special issue includes a series of research and review articles on health equity in the workplace.
- Benach J, Muntaner C, Santana V. Employment conditions and health inequalities: Final report to the WHO Commission on Social Determinants of Health, Employment Conditions Knowledge Network, 2007. World Health Organization. Available at: http://www.who.int/social_determinants/resources/articles/emconet_who_report.pdf.
This comprehensive report provides a global overview of the contribution of working conditions to worldwide health inequalities.
- Morello-Frosch R, Lopez R. The riskscape and the color line: Examining the role of segregation in

environmental health disparities. *Environmental Research* 2006; 102: 181–196.

This paper provides an excellent example of research demonstrating how segregation concentrates economic disadvantage and environmental risks. The authors examine links between racial residential segregation and estimated ambient air exposures to toxic substances and their associated cancer risks, using modeled concentration estimates from the EPA.

- Wilson SM, Heaney CD, Cooper J, Wilson OR. Built environment issues in unserved and underserved African-American neighborhoods in North Carolina. *Environmental Justice* 2008; 1: 63–72.

This article describes built-environment issues that burden communities of color in North Carolina. The authors use a case study from Mebane, North Carolina, to describe how neighborhoods of color in this small town have been impacted by environmental injustice through the denial of basic amenities, especially sewer and water services, and overburdened by unhealthy land uses through inequities in the use of extraterritorial jurisdiction and annexation statutes.

- Bullard RD, Mohai P, Saha R, Wright B. Toxic wastes and race at twenty, 1987–2007: A report prepared for the United Church of Christ Justice & Witness Ministries. 2007. Available at: <https://www.nrdc.org/sites/default/files/toxic-wastes-and-race-at-twenty-1987-2007.pdf>. Accessed February 20, 2017.

This report, essential reading on environmental justice in the United States, discusses exposure disparities at the regional, state, and local level using data on hazardous waste sites. It includes various tools to assess disparities in exposure to, and body burden of, toxic substances among demographic groups.

3

The Roles of Government in Protecting and Promoting Occupational and Environmental Health

Gregory R. Wagner and Emily A. Spieler

This chapter describes a conceptual framework for the roles and responsibilities of government to mitigate occupational and environmental hazards and thereby protect individuals from resultant injury, illness, or death. The focus is on U.S. governmental agencies, but the framework is relevant to other countries, especially those with democratic forms of government. The general principles described are applicable to both occupational and environmental risks, but the specific examples are drawn primarily from the workplace.

From the beginning of recorded history, people have organized themselves into groups of varying size and complexity—from families, to tribes, to nation-states, to multi-state nations, and ultimately into transnational alliances. People organized to protect against external threats and to improve the chance that individuals within the group and the group itself can survive and thrive in challenging and potentially hostile environments. Modern governments act to provide services and protect citizens and other residents from external and internal threats, including threats to public health and welfare.

The preamble to the U.S. Constitution, for example, states: “We the People of the United

States, in Order to form a more perfect Union, establish Justice, insure domestic Tranquility, provide for the common defence, promote the general Welfare, and secure the Blessings of Liberty to ourselves and our Posterity, do ordain and establish this Constitution for the United States of America.” It is this power of the state that underlies laws and policies designed to regulate occupational and environmental hazards.

The scope of government action varies depending on the nature of the challenge and the surrounding economic, political, and social forces. Consider the following examples:

- A worker in a small foundry is concerned about loud noise, heat, and dust. He has recently heard about the cancer risk from silica exposure but does not know if this is something he should worry about. This is the best job available to him, and he does not want to “rock the boat.”
- The parent of a child with asthma is worried that stagnant air and exhaust fumes from nearby highways trigger attacks. The family lives in the northeastern United States and has heard that some of the air pollutants

they inhale come from coal-burning power plants in states to the west.

- A coal mine operator in the midwestern United States is concerned that restrictions on power plants burning coal will force him out of business and his 120 employees out of work.
- A family that owns a small dry-cleaning business learns that the solvent they use to clean clothes will soon be unavailable because of government restrictions. All substitutes are more expensive and would require investment in new equipment. All of their savings are invested in their business. They do not know how to address this problem.

In the first two examples, the individuals are incapable of acting effectively to resolve their concerns adequately. Collective action, often in the form of government intervention, is needed to provide protection for the worker or for the child. This governmental action may be taken at the local, state, or national level. The third and fourth examples illustrate the competing concern that these same government interventions intended to protect the health of the public as a whole may also have adverse effects on specific individuals or businesses. Some businesses may close, with workers losing their jobs; services and goods may become more expensive.

Democratically elected governments do not take action without justification. Elected representatives and governmental agencies have the responsibility to investigate the interests of stakeholders and to understand their concerns and needs, to protect vulnerable people who may not be able to protect themselves, and to attempt to optimize the results of any action – or, alternatively, to justify any decision not to act. Governments are expected—and often legally required—to follow the principles of fairness, nondiscrimination, constraint, and accountability. In public health, laws and policies generally attempt to balance individual and corporate rights against the best collective public health outcome. In this sense, the law serves both as an important tool for achieving public health objectives and, at times, as an obstacle. The right of workers to a safe working environment—or of residents to a safe community—may be compromised or balanced against competing rights of employers and businesses to due process and

protection from excessive government intrusion, rights established by the U.S. Constitution.

Preventive measures to protect health can be developed or implemented by any branch or level of government. In the United States, the federal government has three co-equal branches, each with separate (but interactive) powers and responsibilities:

- The *legislative branch* enacts legislation (laws) and provides resources (through taxation and budget allocation) to implement the laws. In the federal government, this branch is the Congress, which consists of the Senate and the House of Representatives. In occupational health, the most important federal laws are the Occupational Safety and Health Act (OSH Act) and the Mine Safety and Health Act (MSH Act). In environmental health, the most important federal laws include the Environmental Protection Act, the Clean Water Act, the Safe Drinking Water Act, the Clean Air Act, and the Toxic Substances Control Act.
- The *executive branch*, which in the federal government consists of the President and the executive (Cabinet) agencies, is responsible for implementing the laws enacted by Congress and signed by the President. The President can also veto (not sign) a law passed by Congress; if Congress does not override the veto with a supermajority vote, the law will not go into effect. The executive branch can propose legislation and budgets to the Congress. Federal executive agencies include the Department of Labor (in which the Occupational Safety and Health Administration [OSHA] and the Mine Safety and Health Administration [MSHA] are located), the Environmental Protection Agency (EPA), and the Department of Health and Human Services. These executive branch agencies develop regulations (also known as standards or rules) for implementing the laws and enforcing the standards.
- The *judicial branch* (the judiciary) interprets the law. The federal courts determine whether laws passed by Congress are consistent with the U.S. Constitution, and whether actions by executive agencies to implement these laws are consistent with the U.S. Constitution and with the laws as they are passed by Congress.

Box 3-1. Alignment of Political Forces for Protective Legislation

The passage of the federal Coal Mine Health and Safety Act in 1969 was one of the best examples of the alignment of political forces resulting in protective legislation. Coal mining has always been both unsafe and unhealthy. But coal mining takes place out of sight and out of the consciousness of most Americans—in rural, sparsely populated, and, often, economically depressed areas.

This invisibility changed when, in 1968, a fire and explosion ripped through the Farmington Coal Mine near Fairmont, West Virginia, trapping and ultimately killing 78 miners. For weeks, national television news

programs covered this tragedy, with daily pictures and stories documenting the anxiety of miners' families—and eventually their grief when rescue attempts were abandoned.

This recognition of the hazards of coal mining came at a time of social and political activism—supporting the Civil Rights Movement and opposing the Vietnam War. In addition, coal miners, supported by the work of public health professionals, had been organizing demonstrations to bring attention to the disabling, life-threatening lung diseases afflicting coal miners. The result was the passage of comprehensive legislation to protect and compensate coal miners, establish medical surveillance, and promote prevention-focused research.

State and local governments also have similar branches. Laws and regulations vary widely among states and among local government jurisdictions. State legislatures may pass laws pertaining to occupational and environmental health as long as they are consistent with federal laws. (See section on Federalism.)

At any level of government, the development and implementation of new laws, regulations, or other policies require recognition of the existence of a problem, available solutions, financial resources to address the problem, and the popular and political will to act. Without these elements, action will not likely be taken.¹ The passage of the Coal Mine Health and Safety Act of 1969 illustrates this alignment. (See Box 3-1.)

FRAMEWORKS FOR GOVERNMENT ACTION

Governments have a variety of tools to improve prevention of occupational and environmental illnesses and injuries. Once a problem is identified and a commitment is made to address it, people within the government consider options for interventions. Their objective, as a rule, is to prevent disease or injury in the least coercive and most economical manner possible. Government options, ranging from the least to the most coercive, are described in the following sections.

Disseminating Information

The least costly action for a government may be to disseminate existing information to those who

can take useful action. This process may take the form of information releases through the news media and social media; targeted distribution to individuals, employers, or communities affected by the problem; or participation in public meetings or scientific conferences.

The government can, for example, simply make administrative data, such as injury and illness reports, results of worksite inspections, or data on air and water quality, available to anyone who knows how to access these data through governmental agency websites and portals. Federal data are available at www.data.gov. Health and medical publications by government scientists and others can be accessed through the National Library of Medicine. The effectiveness of this kind of passive dissemination depends both on the willingness of the government to make information available, on people's knowledge that the information exists, and on their skills and access to tools that enable the target audience to utilize the information.

Governments may also send messages about specific issues to particular stakeholders. The underlying assumption of this type of *awareness campaign* is that informed stakeholders who can take action are more likely to act if they better understand the issue and the consequences of inaction. For example, MSHA's annual press releases, mailings to mine facilities, and postings to websites remind miners and operators at underground coal mines of the increased risk of mine roof falls during the late fall and early winter.

Governments may also alert the public to enforcement actions that have been taken

against entities that have violated rules. For example, they may provide information to the public about the nature of violations, harms caused, and fines and other actions it has taken to punish a violator. This public communication informs other actual or potential violators that they too might be held accountable and have their reputations tarnished. This strategy, sometimes called *public shaming*, has been shown to be effective in modifying employer behavior.²

Generating and Communicating New Information

Government agencies can generate—and then disseminate—new information by conducting or supporting research or by gathering and performing new analyses of existing data. For example, the National Institute for Occupational Safety and Health (NIOSH), established by the same legislation that created OSHA, is charged with developing new information about occupational hazards and the methods for controlling them. NIOSH conducts research, financially supports nongovernmental research, and makes recommendations to OSHA, state government agencies, employers, workers, and others on the best approaches to recognize and control workplace hazards. The EPA, the National Center for Environmental Health (part of the Centers for Disease Control and Prevention), and the National Institute of Environmental Health Sciences (part of the National Institutes of Health) conduct and support research on environmental hazards. Other government agencies, such as the Department of Energy, may support research that can be used to inform the public about occupational and environmental health and safety hazards. The results of all relevant scientific research inform government decisions concerning new and existing regulations and other policies.

Providing Guidance and Advocating for the Establishment of Improved Norms

Government agencies routinely communicate nonenforceable guidelines or recommendations to reduce risk based on the best available information. For example, NIOSH is legislatively

mandated to develop and update recommended exposure limits for toxic substances found in workplaces. While these guidelines do not set legally-enforceable limits, they nevertheless provide information to employers and workers about risks that may be inadequately regulated (either because there is no rule or because new information has shown that the legal limit is not adequately protective) and ways in which these risks can be reduced.

Many agencies charged with health protection also produce and communicate recommendations for improved practices. For example, OSHA and NIOSH have jointly issued guidance for protecting workers in hot environments. The EPA has issued many guidance documents advising employers and communities on ways to comply with environmental regulations. While guidelines are not legally enforceable, a government agency can encourage establishment of new norms of exposure or activity and facilitate voluntary implementation of preventive measures by issuing guidelines (recommendations). In addition, government agencies may sometimes issue guidelines when there is sufficient information to encourage action on a significant problem, but there are barriers to developing formal regulations.

The government may also certify the adequacy of certain protective approaches. For example, NIOSH tests respiratory protective devices, classifies them, and certifies that specific models perform as advertised in the environments where they are intended to be used. Individuals or companies can use this certification to determine what equipment to purchase and use for protection against workplace hazards. When regulations mandate use of respiratory protection, only certified respirators may be used.

Providing Incentives for Health Protective Actions

The government may establish incentives for employers to voluntarily adopt measures for protection of health. For example, the OSHA Voluntary Protection Program encourages employers to develop and implement comprehensive health and safety management programs relevant to their industry and enterprise.

Tax policy is frequently used to encourage voluntary adoption of societally-desirable practices. For example, businesses and individuals may be given subsidies in the form of credits against taxes if they spend money on solar panels for generation of clean energy or on more efficient heating or air-conditioning systems. Favorable tax treatment may encourage the purchase of new, safer equipment. The tax code may provide incentives for specific actions without penalizing those who cannot—or choose not to—take advantage of the incentives.

Establishing and Enforcing Standards and Regulations

Formal enforceable regulations, which are promulgated by the executive agencies, are essential tools for reducing occupational and environmental health and safety risks. Without regulations, employers and businesses may not have sufficient motivation and may lack adequate financial incentive to reduce these risks. For example, much of the cost of occupationally related deaths and disabilities is externalized from workplaces, and the costs are borne by entities other than the employer.^{3,4}

Effective regulatory intervention requires all of the following:

1. A law that sets out the principles and justification for regulation
2. An agency with expertise to decide what hazards warrant intervention and to develop specific rules governing intervention
3. Enforcement methods to ensure adequate compliance with both general and specific regulatory requirements
4. Dissemination of information to affected parties regarding the regulatory requirements
5. Protection of workers or community members who initiate and participate in enforcement activities.

Because establishing regulations (standard setting) and implementing them (inspection and enforcement) are central to the federal government's role in preventing occupational and environmental illnesses and injuries, the following section describes this approach in detail.

THE U.S. REGULATORY SYSTEM

Occupational Safety and Health

The two primary federal laws governing occupational safety and health are the OSH Act,⁴ which covers general industry, and the MSH Act,⁵ which covers coal, metal, and non-metal mining as well as quarrying. Other federal laws govern health and safety in specific industries, including railroads, trucking, nuclear energy, and agriculture (for pesticide use).

The Occupational Safety and Health Act

Until 1970, there was no comprehensive federal law concerning occupational safety and health in general industry. Early in the 20th century, the U.S. Supreme Court even limited the right of states to regulate working conditions. But the understanding of the federal government's powers changed during the first half of the 20th century. A broader interpretation of the Interstate Commerce Clause of the U.S. Constitution meant that Congress could enact federal laws in a wide variety of areas, including occupational and environmental health. In response to growing public concern about workplace hazards, in 1970 Congress passed, and President Richard Nixon signed, the OSH Act. Congress justified the law on economic grounds, noting that occupational injuries and illnesses impose a substantial burden on interstate commerce with lost production, wage loss, medical expenses, and payment for disability compensation.

The OSH Act expresses a lofty goal:

To assure safe and healthful working conditions for working men and women; by authorizing enforcement of the standards developed under the Act; by assisting and encouraging the States in their efforts to assure safe and healthful working conditions; by providing for research, information, education, and training in the field of occupational safety and health; and for other purposes.

The Act also states that any regulation pertaining to toxic materials or harmful physical agents must assure, to the extent feasible, that no workers will suffer impairment of health or functional

capacity even if they have regular exposure to a hazard for their entire working lives.

The OSH Act established two agencies: OSHA to develop regulations (standards) and enforce the law and NIOSH to perform research and provide OSHA with scientifically based recommendations. OSHA promulgates regulations that cover specific hazards and issues orders (citations) to employers who are not in compliance with the law. The OSH Act created a separate adjudicatory body, the Occupational Safety and Health Review Commission (OSHRC), to settle disputes when employers challenge OSHA enforcement actions. The OSH Act permits enforcement of OSHA regulations by state agencies in certain circumstances. (See the later discussion of federalism to understand the interaction between federal and state government agencies.)

The primary focus of OSHA is the responsibility of employers to maintain safe workplaces. To comply with the law, every employer has two primary duties: (a) to furnish each employee employment and a place of employment that are “free from recognized hazards that are causing or are likely to cause death or serious physical harm” (in compliance with the General Duty Clause) and (b) to comply with occupational safety and health standards promulgated by OSHA. Employees also must comply with regulations relevant to their own individual actions and conduct.

Even if there is no specific standard that regulates a hazard, the General Duty Clause obliges employers to provide safe workplaces. Because the process of setting standards (promulgating regulations or making rules) is very slow, the General Duty Clause has special significance. OSHA can cite employers under the General Duty Clause for hazards not covered by other regulations and for more generalized serious hazards.

OSHA may develop a standard when an assessment demonstrates that a hazard is (a) sufficiently widespread and (b) causes illnesses or injuries that can be reduced or controlled by methods that are technologically and economically feasible. OSHA promulgates permanent standards, interim standards, and emergency temporary standards.

When the OSH Act was passed, it authorized the initial issuance of interim standards,

without adhering to the formal rulemaking procedure required for new permanent standards. These interim standards, known as *consensus standards*, were based on existing recommendations from professional organizations or existing rules developed under old laws. In 1971, OSHA promulgated 4,400 federal consensus standards under this rulemaking authority. The interim standards remained in effect until revoked or revised using the procedure for new permanent standards. OSHA’s power to set interim standards expired in 1973. Because OSHA has had difficulty in issuing permanent standards, many of these initial standards are still in effect.

Since 1973, OSHA has been authorized to issue only permanent standards or emergency standards and must meet strict substantive and procedural requirements. In order to issue a permanent standard, OSHA must demonstrate all of the following:

1. The targeted hazard, if left unregulated, would pose a significant risk of injury or death. In developing standards, OSHA, in response to judicial decisions, has decided not to propose new standards without scientific evidence that shows that workers exposed to the substance or hazard for their working lifetimes will experience at least a one-in-a-thousand (0.1%) risk of death or serious harm.
2. The proposed change (such as reduction in exposure or change in workplace design) will result in a demonstrable reduction in this risk.
3. The imposed regulation is based on the best available scientific information.
4. The proposed regulation is both technically and economically feasible. (Economic feasibility focuses on the viability of an entire industry, not individual employers in that industry.)

Permanent standards, particularly those that regulate toxic substances, are often quite complex. They set exposure limits, identify specific methods for hazard control, and mandate required training of workers. Several health standards also require medical monitoring to try to identify workers with excessive exposure

or subclinical disease and provide them with therapeutic or preventive interventions. (For example, the OSHA lead standard provides for temporary transfer for workers who have elevated blood lead levels to jobs with lower or no lead exposure.)

To issue a *permanent standard*, OSHA must follow a strict administrative process, set out in the Administrative Procedures Act, which requires:

1. Publication of an initial intent to engage in rulemaking
2. Publication of the proposed standard
3. A sufficient period for the agency to receive comments and hold public hearings
4. Finally, promulgation of the final rule, including the agency's justification and responses to the comments.

Standards are then subject to rigorous judicial review if challenged by an affected party. Every recent OSHA and MSHA standard has been challenged by businesses, business associations, or unions. The judicial review process can be lengthy. (Some of the steps in the standard-setting process are illustrated in Figure 3-1.)

Without conducting hearings or using advisory committees, OSHA may issue a *temporary emergency standard*, which is effective immediately upon publication. To do so, OSHA must show that “employees are exposed to grave danger from exposure to substances or agents determined to be toxic or physically harmful or from new hazards” and that the standard “is necessary to protect employees from such danger.” A temporary emergency standard can be in effect only for 6 months. OSHA has, since 1971, issued only nine temporary standards, five of which were rescinded when they were successfully challenged in court.

Enforcement

All federal health and safety laws are based on the concept of *preinspection compliance*. The laws assume that employers will comply in order to prevent illnesses and injuries—not that the agencies will be able to inspect every employer before an illness or injury occurs or that deterrence will be achieved by punishment after it occurs.

OSHA is not required to inspect the workplaces of every employer. Fines for violations

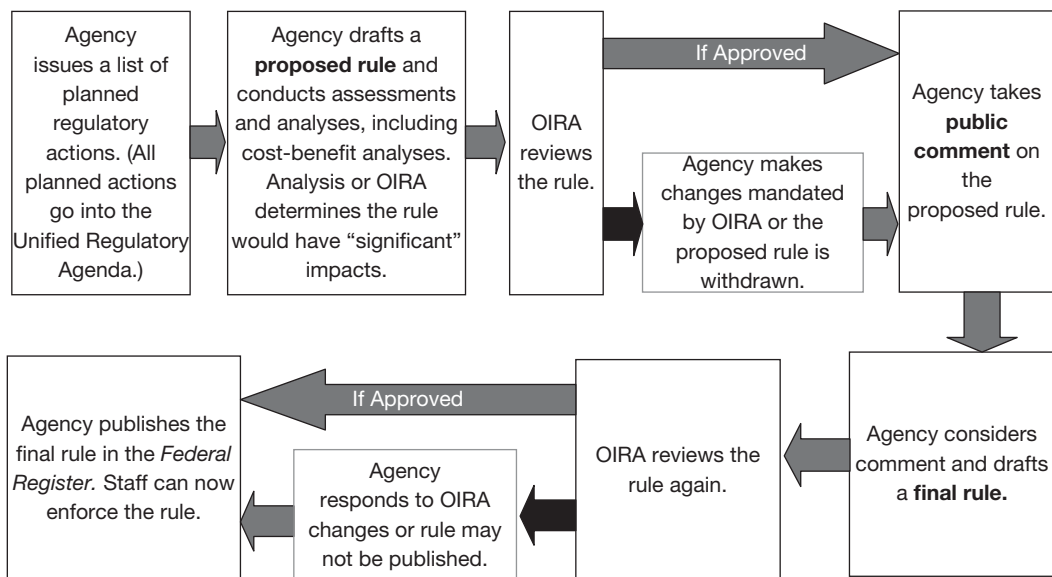


Figure 3-1. Steps in federal rulemaking for significant rules (over \$100 million annually in costs or new policy issues). Note. OIRA, Office of Information and Regulatory Affairs. (Project on Government Oversight.)

are relatively low, and criminal sanctions are limited. The OSHA inspection force is also very small compared to the breadth of its jurisdiction; there are 2,200 federal and state inspectors (compliance officers) responsible for the health and safety of 130 million workers, employed at more than 8 million worksites in the United States—about one for every 59,000 workers. According to one analysis, OSHA is able to inspect each U.S. workplace about once a century, on average, with current staffing levels.⁶ Given these constraints, expecting and requiring employers to comply with the OSH Act *before* or in the absence of an inspection is the only possible approach that will result in effective prevention.

OSHA is empowered to enter and inspect workplaces, to levy civil penalties, and to bring criminal actions against employers for failing to comply with either specific standards or the General Duty Clause. Compliance officers from OSHA's regional and district offices, located throughout the United States, inspect workplaces to determine if employers are in compliance with all applicable standards and the General Duty Clause. OSHA's operating procedures are set out in its field operations manual, which includes guidelines for selecting workplaces to be inspected and procedures for inspections, preparation of citations, and assessment of penalties.

The OSH Act established the following general priorities for inspections:

1. Imminent danger investigations
2. Investigations of fatalities and catastrophes involving three or more employees
3. Investigations of complaints
4. Targeted or programmed inspections, generally in industries where there is particular concern due to especially high rates of injuries or toxic exposures
5. Follow-up inspections (to ensure that an employer has achieved full compliance after prior inspections). These inspections may receive higher priority in high-risk industries or when the employer is a repeat violator.

When conducting an OSHA inspection, the compliance officer first presents credentials to the employer and then conducts an

inspection tour of the facility (a *walkaround*). If the employer refuses to allow the inspector to enter, OSHA will seek an administrative search warrant from a federal district court; administrative search warrants are routinely issued. The employer has a right to accompany the inspector on the walkaround. An employee representative may also participate in the walkaround, although inspections are not invalidated by the lack of an employee representative and employers are not required to pay workers for their time spent on walkarounds. In general, workers assert their rights to participate in walkarounds more frequently in workplaces that are unionized.

After the inspection, the compliance officer convenes a closing conference to discuss safety and health conditions and possible violations. The inspector then returns to the OSHA regional or district office and confers with supervisors to determine what, if any, citations will be issued. All citations provide details regarding the specific violations, any proposed penalties, and the time limits (*abatement periods*) for the employer to correct the violations. Penalties depend on the seriousness of the violation. OSHA can bring criminal charges in certain circumstances for willful violations of standards.

If an imminent danger is present at the facility, the compliance officer will inform the employees and the employer. Although OSHA cannot immediately stop any work, OSHA may seek an order from a federal district court requiring the employer to eliminate the imminent danger. The on-site compliance officer has no authority to stop any work, no matter how dangerous, without a court order.

An employer has the right to challenge any aspect of a citation within 15 working days. In contrast, employees and their representatives have limited rights; if the employer does not challenge the citation, employees can only challenge the duration of the abatement period. However, if the employer challenges the citation, the employees' representative may request formal involvement in the proceedings that follow. Administrative law judges within OSHRC hold hearings on employer challenges to citations, and the Commission rules on appeals of these judges' decisions. Appeals of Commission decisions go to a U.S. Circuit Court of Appeals.

The employer has no obligation to abate a hazard during any pending challenge to the citation. Citations are therefore often settled for reduced penalties in order to induce the employer to address the hazard at the workplace more quickly.

Voluntary Consultations

Given the vast number of workplaces and the shortage of OSHA inspectors, several administrative programs seek voluntary compliance with OSHA regulations. On-site consultation services, funded by OSHA, are provided free of charge; priority is given to small businesses and companies in hazardous industries.

OSHA also operates two programs that give special privileges to approved employers including exempting them from OSHA programmed inspections. Its Voluntary Protection Program recognizes employers that have implemented effective safety and health management systems and maintain injury and illness rates below national averages for their industries. Its Safety and Health Achievement Recognition Program recognizes small businesses that operate “exemplary” injury and illness prevention programs.

Workers’ Rights under the OSH Act

Under the OSH Act, workers have several rights, including:

- Protection from retaliation for raising concerns about safety or notifying their employers about injuries
- Exemptions from being fined for violations of the Act found on workplace inspections
- Limited rights to participate in inspections and appeals of citations against employers
- The right to participate, personally or through their unions, in the public process for development of new standards.

Mine Safety and Health

Underground mining has long been recognized as extremely hazardous. Federal safety and health regulation of mining began earlier than in general industry. Multiple mining disasters resulted in progressively stronger attempts by the federal government to improve mine safety. Starting in

1941, federal mine inspectors were given a legal right to enter mines, and, in 1947, the first legally enforceable federal mine safety regulations were authorized by Congress.

Over time, authority to regulate safety grew as did the mandate to inspect and enforce regulations. Responding to increasing public concerns about the health and safety of coal miners, Congress passed the Coal Mine Safety and Health Act of 1969. The Act established more stringent requirements, including financial penalties for violations of regulations; a limit to coal mine dust exposure; and a health surveillance program for coal miners. The Act also mandated regular inspection of all mines and created a federal compensation system for victims of severe lung disease from coal mine dust (“black lung” disease). In 1977, after a mine disaster in Kentucky caused 27 deaths, Congress strengthened mine safety laws by passing the Federal Mine Safety and Health Act (the Mine Act), which consolidated responsibility for regulating and inspecting coal mines as well as metal mines and rock quarrying in MSHA. The Mine Act expanded the rights of miners to request inspections when they identified hazardous conditions and improved miners’ protection from retaliation for expressing concerns about safety or health. The Act also enabled MSHA to impose severe penalties on mine operations with a “pattern of violations” indicating an unwillingness to comply with mining safety laws.

The administrative and adjudicative structure of MSHA is similar to that of OSHA. Appeals of citations go to the Mine Safety and Health Review Commission, a separate agency similar to OSHRC.

Reflecting the widely held view that mines are more dangerous than other workplaces, the Mine Act is stronger than the OSH Act in several ways:

- It provides for mandatory comprehensive inspections of all mines: four times a year for all underground mines, twice a year for all surface mines.
- Inspectors have on-site authority to shut down an operation if it poses an imminent danger to workers.
- Workers who accompany inspectors on walkarounds must be paid for their time.

- Fines are higher than in general industry.
- Employers must abate hazards immediately, even if they appeal citations or fines.
- Protection for workers against retaliation is stronger, including an immediate right to reinstatement if they are discharged, as long as their claims are not viewed as “frivolous.”
- State agencies can establish parallel mine safety programs that do not displace any federal regulatory or enforcement programs.

Environmental Health

In the United States, interest in environmental protection arose from a commitment to the preservation of unspoiled areas of wilderness (generally for recreational purposes) and a desire to protect people from health threats posed by toxic contamination of air, water, and soil. Historically, regulatory authority to protect the environment had been spread among multiple federal and state agencies, without coordination or sufficient attention to a scientific foundation for environmental policy.

In the 1960s, growing attention to the threat of toxic pollutants, in part sparked by the book *Silent Spring* by Rachel Carson, drew attention to the hazards posed by DDT and other pesticides and encouraged environmental and political movements that advocated for increased environmental protections.⁷ In response, President Nixon proposed and Congress passed the National Environmental Policy Act of 1969 to improve coordination of environmental policy formation, regulation, and scientific research. The stated goals of the Act were to:

- Fulfill the responsibilities of each generation as trustee of the environment for succeeding generations
- Assure for all Americans safe, healthful, productive, and esthetically and culturally pleasing surroundings
- Attain the widest range of beneficial uses of the environment without degradation, risk to health or safety, or other undesirable and unintended consequences

- Preserve important historic, cultural, and natural aspects of our national heritage, and maintain, wherever possible, an environment that supports diversity and variety of individual choice
- Achieve a balance between population and resource use, which will permit high standards of living and a wide sharing of life's amenities
- Enhance the quality of renewable resources and approach the maximum attainable recycling of depletable resources.

The Act established the Environmental Planning Council and mandated broad responsibilities for assessing the environmental impact of federal government activities. The Act was soon followed by a reorganization of federal agencies, resulting in the consolidation of responsibilities related to health protection from environmental pollution into the EPA. President Nixon, in proposing the creation of the EPA, said it was needed to:

- Establish and enforce environmental protection standards consistent with national environmental goals
- Conduct research on the adverse effects of pollution and on methods and equipment for controlling it, gather information on pollution, and use this information for strengthening environmental protection programs and recommending policy changes
- Assist others, through grants, technical assistance, and other means, in arresting pollution of the environment
- Assist the Council on Environmental Quality in developing and recommending to the president new policies for the protection of the environment.

The EPA is responsible for enforcement of several laws relating to environmental protection, including the Clean Air Act (see Chapter 15), the Clean Water Act, and the Safe Drinking Water Act (see Chapter 16), as well as laws governing hazardous wastes (see Chapter 18) and protection of endangered species. (Details of these laws are described in the cited chapters.)

CONSTRAINTS ON GOVERNMENT ACTIONS

Government actions attempt to balance a range of conflicting social, political, and economic interests. Although the potential for the federal government to protect against occupational and environmental hazards is broad, there are substantial constraints, both within and external to the government. Mandatory inclusion of stakeholder input to priority setting, regulation, and actions provides transparency but also reduces government decision latitude.

Budgetary and Other Legislated Constraints

The executive branch proposes budgets, but the legislative branch, through taxes and fees, raises and allocates money for all government activities. Executive agencies, such as OSHA, MSHA, and EPA, may only spend money on programs specifically authorized by legislation, and they cannot spend more money than they are allocated. In addition, Congress can restrict spending on specific activities that appear to be within the domain of particular agencies. The legislative budgeting process can result in limitations on agency actions in two ways. First, the budget may be inadequate to support some activities. For example, OSHA's budget is insufficient to hire and train enough compliance officers to inspect all workplaces. Second, Congress may restrict the use of funds for specific purposes that would appear to be within the agency's powers. For example, Congress does not permit OSHA to use authorized funds for routine inspections of agricultural worksites, thereby limiting the protection of agricultural workers. Small businesses employing fewer than 10 people are also exempted from routine inspections.

The Congressional Review Act (CRA) allows Congress to review and override regulations that have been legally developed and issued. For example, in 2001, Congress nullified a comprehensive occupational ergonomics rule that was issued by OSHA; since then, OSHA has been precluded from developing a new standard to protect workers from ergonomic hazards. This was the only time the CRA was used prior to 2017, when it was employed to overturn several

federal regulations, including an OSHA regulation that had clarified OSHA's ability to cite employers for failure to maintain records of injuries and diseases for the 5 years prior to an inspection.

The Office of Information and Regulatory Affairs (OIRA), established by a Presidential executive order, exerts the primary constraint within the executive branch on agencies developing and issuing regulations. OIRA assures that government activities and demands on citizens are not burdensome. The executive order mandated OIRA involvement in all rule-making and set out the following guiding philosophy:

- Federal agencies should promulgate only regulations that are required by law, necessary to interpret the law, or made necessary by compelling public need, such as material failures of private markets to protect or improve public health and safety or the environment.
- In deciding whether and how to regulate, agencies should assess all costs and benefits of available regulatory alternatives, including the alternative of not regulating. Both quantifiable and qualitative measures of costs and benefits should be considered.
- In choosing among alternative regulatory approaches, agencies should select those approaches that maximize net benefits (including potential economic, environmental, public health and safety, and other advantages; distributive impacts; and equity), unless a statute requires another regulatory approach.⁸

Compliance with this executive order means that all proposals from executive agencies to issue regulations pass through OIRA for review and approval before being made public (Figure 3-1). OIRA may refuse permission to issue a rule because of insufficient justification, excessive cost, or a belief that the issuing agency has not been sufficiently thorough in exploring alternatives to the proposed regulation. Proposed rules that pass OIRA review are then made available for a period of public comment, after which agencies revise or abandon the proposed rules. Any revised rules must be approved

again by OIRA before being issued. The result of this often-lengthy deliberative process is that OSHA infrequently issues regulations, and those regulations that it does issue take many years to develop.⁹

PUBLIC ENGAGEMENT IN THE REGULATORY PROCESS

Throughout the regulatory process, there are many opportunities for public engagement to either encourage or oppose government actions. Individuals and organizations may informally ask government agencies to pay attention to their specific concerns. If they are unsatisfied, they may formally petition agencies to take action. Agencies are obligated to publish a *regulatory agenda*, identifying the regulations that they are considering or developing and the status of their work on these regulations. Members of the public may comment on the published agenda to encourage agencies to accelerate or slow action.

Agencies frequently make formal *requests for information*, asking individuals, organizations, and other government agencies to provide information relevant to developing a regulation in order to assure that they are acting, as legally mandated, on the best available information. Organizations and individuals may interact with OIRA during the regulatory process to try to ensure that their concerns are being addressed.

Once a regulation is formally proposed, there is a public comment period, during which individuals and organizations are encouraged to submit comments on the proposal. Each of the comments is reviewed by the agency and must be considered and addressed in the framing of the final regulation.

Organizations or individuals who believe that they will be adversely affected by a regulation can seek judicial review, if they feel that the proper procedures were not followed by the agency in developing the regulation.

There are formally established independent federal advisory committees, such as the Advisory Committee on Construction Safety and Health, the National Advisory Committee on Occupational Safety and Health, the Mine Safety and Health Research Advisory Committee, and

the Clean Air Scientific Advisory Committee, which provide advice to the regulatory agencies. Agencies may also establish ad hoc advisory committees to focus on a specific hazard or in response to petitions requesting rule-making. Representatives of stakeholder organizations also have frequent informational meetings with staff members of regulatory agencies in order to remain current regarding regulatory and enforcement policies and scientific developments.

FEDERALISM AND THE ROLE OF STATE AND LOCAL GOVERNMENTS

The concept of *federalism* guides and constrains the actions of the U.S. government in addressing occupational and environmental threats. The federal government's ability to act is framed by the U.S. Constitution. Whatever powers are not specifically granted to the federal government are held by the states. As the understanding and interpretation of federal powers broadened through the 20th century, the balance between federal authority on the one hand and state and local authority on the other has evolved.

The federal government's authority to regulate occupational and environmental health is largely derived from the Interstate Commerce Clause of the Constitution. Regulated activity therefore must, in some way, involve activities that cross state boundaries. Today, because of the interconnectedness of the economy and the nature of commerce, the reach of the federal government is deep and broad. However, the federal government may also delegate some of its regulatory and enforcement powers to states. This somewhat complex relationship plays out differently under the different federal laws.

The OSH Act provides that states may develop their own state plans, apply for federal approval, and then enforce the OSH Act, *replacing* the enforcement structure of the federal government described previously. Currently, 26 states have approved state plans, of which 21 cover both private-sector and public-sector (government) workers; the remaining five states cover public-sector workers only. State plans for the private sector must be at least as protective as the OSH Act requirements. These states can also