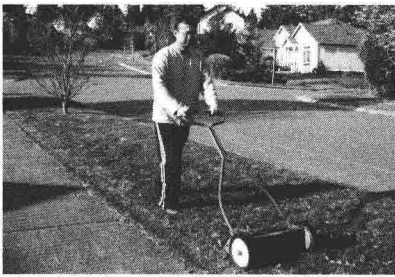
A full-page photograph of a man running on the Golden Gate Bridge. The man is in the foreground, seen from behind, wearing a dark blue long-sleeved shirt, dark shorts, and white sneakers with blue accents. He is running on the pedestrian path of the bridge. The bridge's iconic red-orange towers and suspension cables are visible in the background against a clear blue sky. A cyclist is visible further ahead on the same path. The overall scene conveys a sense of physical activity and health.

FOUNDATIONS OF PHYSICAL ACTIVITY AND PUBLIC HEALTH

HAROLD W. (BILL) KOHL, III
TINKER D. MURRAY

FOUNDATIONS OF PHYSICAL ACTIVITY AND PUBLIC HEALTH



Harold W. (Bill) Kohl, III, PhD, FNAK, FACSM

University of Texas Health Science Center at Houston
University of Texas at Austin, United States



Tinker D. Murray, PhD, FACSM

Texas State University
San Marcos, Texas, United States



Human Kinetics

Library of Congress Cataloging-in-Publication Data

Kohl, Harold W., 1960-

Foundations of physical activity and public health / Harold W. Kohl III and Tinker D. Murray.

p. ; cm.

Includes bibliographical references and index.

ISBN 978-0-7360-8710-0 (hard cover) -- ISBN 0-7360-8710-9 (hard cover)

I. Murray, Tinker Dan, 1951- II. Title.

[DNLM: 1. Exercise. 2. Health Promotion--methods. 3. Public Health. QT 255]

613.7'1--dc23

2011045270

ISBN-10: 0-7360-8710-9

ISBN-13: 978-0-7360-8710-0

Copyright © 2012 by Harold W. Kohl, III, and Tinker D. Murray

All rights reserved. Except for use in a review, the reproduction or utilization of this work in any form or by any electronic, mechanical, or other means, now known or hereafter invented, including xerography, photocopying, and recording, and in any information storage and retrieval system, is forbidden without the written permission of the publisher.

The web addresses cited in this text were current as of October 2011, unless otherwise noted.

Acquisitions Editor: Myles Schrag

Developmental Editor: Judy Park

Assistant Editor: Brendan Shea, PhD

Copyeditor: Patsy Fortney

Indexer: Bobbi Swanson

Permissions Manager: Dalene Reeder

Graphic Designer: Joe Buck

Graphic Artist: Tara Welsch

Cover Designer: Keith Blomberg

Photographs (interior): © Human Kinetics, unless otherwise noted

Photograph (cover): © Joshua Huber/Aurora Photos

Photo Asset Manager: Laura Fitch

Visual Production Assistant: Joyce Brumfield

Photo Production Manager: Jason Allen

Art Manager: Kelly Hendren

Associate Art Manager: Alan L. Wilborn

Printer: Sheridan Books

Printed in the United States of America 10 9 8 7 6 5 4 3 2 1

The paper in this book is certified under a sustainable forestry program.

Human Kinetics

Website: www.HumanKinetics.com

United States: Human Kinetics

P.O. Box 5076

Champaign, IL 61825-5076

800-747-4457

e-mail: humank@hkusa.com

Canada: Human Kinetics

475 Devonshire Road Unit 100

Windsor, ON N8Y 2L5

800-465-7301 (in Canada only)

e-mail: info@hkcanada.com

Europe: Human Kinetics

107 Bradford Road

Stanningley

Leeds LS28 6AT, United Kingdom

+44 (0) 113 255 5665

e-mail: hk@hkeurope.com

Australia: Human Kinetics

57A Price Avenue

Lower Mitcham, South Australia 5062

08 8372 0999

e-mail: info@hkaustralia.com

New Zealand: Human Kinetics

P.O. Box 80

Torrens Park, South Australia 5062

0800 222 062

e-mail: info@hknewzealand.com

To our colleagues and their students, who will improve public health by zealously promoting science and the practice of physical activity in individuals and in populations.

PREFACE

Welcome to *Foundations of Physical Activity and Public Health*. This text is a collection of the concepts that define the emerging field of physical activity and public health. Much like the more established fields (i.e., the effects of nutrition and smoking on public health), physical activity and public health has its roots in the grafting of two other fields. In this case, public health scientists and exercise scientists have come together to create a window to improve health through research and promotion of physical activity. Methods and evidence from the public health sciences (epidemiology, health promotion, behavioral science, and environmental health) and kinesiology (exercise physiology, the movement sciences, and sport and exercise psychology), combined with a necessary eye on health policy, constitute our field. Although nothing can be substituted for experience, this text offers the background and introduction to tools needed for the planning, implementation, and evaluation of physical activity promotion programs. This is the first textbook of its kind designed for a semester-long course in the field.

Few singular health behaviors can have as broad an impact on the health of individuals and populations as does physical activity. The scientific base is growing and solidifying regarding the effects of physical activity on all-cause morbidity and mortality due to multiple noncommunicable diseases such as heart disease, some cancers, diabetes, and osteoporosis.

It is a very exciting time of growth in physical activity and public health. The seminal scientific works of Dr. Jeremy N. Morris and Dr. Ralph S. Paffenbarger Jr. helped set the stage for what is now a worldwide focus on advancing the science as well as reducing physical inactivity and promoting the benefits of regular physical activity for the prevention and treatment of chronic diseases and other health challenges. As the science and practice advance, physical activity is receiving increased attention from policy and organizational decision makers worldwide, including governmental ministers of health. Professional societies have been created to focus on advancing the research and practice of the field, the scientific literature has expanded dra-

matically on multiple fronts, and physical activity and inactivity are becoming parts of health policy decisions at all levels. An outstanding example is the Toronto Charter for Physical Activity: A Global Call to Action (www.globalpa.org.uk/charter). This advocacy tool drives policies worldwide that are supportive of the role of physical activity in promoting health.

HOW THIS BOOK IS ORGANIZED

Foundations of Physical Activity and Public Health is organized into three parts and 16 chapters.

PART I: INTRODUCTION TO PHYSICAL ACTIVITY AND PUBLIC HEALTH

Part I introduces concepts of public health, kinesiology, and measurement. The chapters in this part highlight fundamentals of each and how they have come together.

Chapter 1 introduces the fundamentals of public health and provides information about the various subdisciplines of public health and how public health differs from medicine. Finally, there is a discussion about how public health policy is often linked to the legal and regulatory system as well as discussion of an emerging specialization in public health.

The fundamentals of kinesiology are discussed in chapter 2. In the past, exercise was studied and often promoted as a means of enhancing maximal performance rather than promoting basic health benefits for all. The components of exercise training are presented as well as the methods for applying them to target populations. The general health, fitness, and performance effects of physical activity and exercise are discussed. A final section presents ways to integrate traditional exercise prescription into physical activity and exercise programs.

Chapter 3 focuses on the emergence of the subdiscipline of physical activity and public health. Examples of the interdisciplinary interest in the field of physical activity and public health are reviewed

and the knowledge, skills, and aptitudes for careers in physical activity and public health are provided.

In chapter 4, the importance of measuring physical activity is introduced and the strengths and weaknesses of various laboratory and field methods are discussed. Overviews of the following techniques are included: indirect calorimetry, doubly labeled water, accelerometers, pedometers, direct observation, and self-report instruments. Observational techniques such as physical activity surveillance and sources of data-based comparison are also discussed.

PART II: HEALTH EFFECTS OF EXERCISE AND PHYSICAL ACTIVITY

The scientific base of the health effects of physical activity and inactivity is remarkable in its size and complexity. It continues to grow each year, and the overwhelming evidence for the health benefits and risks of physical activity provides much of the rationale for action.

Cardiovascular and metabolic diseases and their relations to physical activity are presented in chapter 5. The chapter starts with a discussion of the prevalence and economic costs of cardiovascular and metabolic diseases. Specific physiological, biomechanical, and behavioral adaptations to physical activity and exercise are also identified. Common testing methodologies for predicting and diagnosing metabolic disease are provided. The evidence for the effect of physical activity on cardiorespiratory and metabolic disease is discussed.

Chapter 6 contains common definitions for overweight and obesity and a discussion about the prevalence (U.S. and worldwide) and the economic costs of these conditions. A discussion of caloric balance is included, and the contributions that physical activity and exercise have on balance are highlighted. The various risk factors associated with overweight and obesity are discussed and specific physiological, biomechanical, and behavioral adaptations to physical activity and exercise are identified. Methods for assessing body composition are provided. The effects of physical activity on weight loss, weight maintenance, and weight regain are discussed along with the physical activity guidelines for achieving caloric balance and a healthy weight.

Chapter 7 focuses on musculoskeletal disorders and functional health. The risk factors, prevalence,

and economic costs of musculoskeletal disorders and disability are discussed. Specific physiological, biomechanical, and behavioral adaptations to physical activity and exercise are provided. Common testing methodologies for muscle function and functional health are included. The evidence for the effect of physical activity on musculoskeletal disorders and disability in functional health is discussed.

In chapter 8, cancers related to physical inactivity are discussed and the prevalence of each is highlighted. The mechanism by which physical activity might reduce the risk of some cancers is included along with a discussion of common risks for cancer. Specific physiological, biomechanical, and behavioral adaptations to physical activity and exercise are identified. Included is a discussion of scientific evidence supporting the benefits of physical activity for cancer survivors as well as evidence for the role of physical activity in the prevention of cancer.

Chapter 9 examines the effects of physical activity on mental health. The prevalence, economic costs, and risk factors of mental health disorders are discussed. A framework for studying mental health problems and their response to physical activity interventions is provided along with a discussion about the effects of physical activity on brain function: reaction time, learning tasks, cognitive function, and academic achievement. The recommendations for physical activity complete the chapter.

In chapter 10, adverse events associated with physical activity are discussed. Participation in regular physical activity and exercise may increase the risk of musculoskeletal injuries and sudden cardiac death in some cases. The chapter contains a discussion about defining adverse events, the prevalence of problems, the risks associated with injury, and the adaptive processes that may help prevent injury.

PART III: STRATEGIES FOR EFFECTIVE PHYSICAL ACTIVITY PROMOTION

The chapters in part III introduce evidence-based strategies for increasing physical activity in individuals and populations. Public health is characterized by translating science into action for advancing the health of the population. The strategies presented in part III have been scientifically demonstrated to increase physical activity and can be used for action in a variety of settings.

Methods for promoting physical activity are discussed in chapter 11, which opens with a discussion about the importance of using the Guide to Community Preventive Services as a resource for identifying physical activity intervention programs that work. A discussion about the impact of community-wide campaigns on increasing physical activity is included along with an overview of mass-media campaigns.

In chapter 12, the rationale for school-based physical activity interventions is presented. The scientific benefits of physical activity in youth are reviewed, and commonly used physical fitness tests for school settings are discussed. A section that highlights current U.S. strategies and policies for promoting physical activity via school-based programs is included. The remainder of the chapter focuses on examples of evidence-based school physical activity programs.

In chapter 13, the focus is on evidence-based strategies for behavioral and social approaches to physical activity promotion. The chapter includes a discussion of current behavioral theories and theoretical models that are used to explain physical activity behavior in individuals. Social support strategies for physical activity promotion in communities are defined and highlighted, and examples of both types of approaches are provided.

In chapter 14, environmental and policy influences on physical activity are reviewed, as are strategies for change. The ways in which aspects of the physical and built environment can encourage or inhibit physical activity are reviewed. The role of urban design for physically active populations and evidence-based strategies for change are discussed.

In chapter 15, evaluation of physical activity programs is introduced. The chapter begins with a discussion of the six-step Physical Activity Evaluation Framework developed by the Centers for Disease Control and Prevention (CDC). The concepts of formative evaluation, process evaluation, outcome evaluation, and cost-effectiveness evaluation are covered. Logic models are presented. The chapter also contains discussions about evaluation designs, data collection and analysis, and publishing and communicating results.

Chapter 16 is the final chapter in the text, which focuses on building effective partnerships for physical activity programs. Examples of effective partnering include a state plan (Active Texas

2020), the U.S. National Physical Activity Plan, and the international Toronto Charter for Physical Activity. Strategies for physical activity advocacy are included, and models for advocacy and effective leadership conclude the chapter.

SPECIAL FEATURES

The content and chapter organization of *Foundations of Physical Activity and Public Health* is based on contemporary teaching principles to maximize learning opportunities for students. Following are the features in each chapter:

- *Objectives* are summaries of take-away messages you should learn by reading and studying the material.
- *Opening questions* help you think about how you can use information in the text.
- *Highlight boxes* are examples of topics covered in the text, which will help you translate theory into practice.
- *Case studies* are real-life examples of selected concepts covered in the chapter, and are found in part III.
- *Key leader profiles* are mini-biographies of world leaders in physical activity and public health. Each leader addresses four key questions about his or her work in the field.
- *What you need to know* is a bulleted review of the chapter to help you study the information provided.
- *Terms to know* are the key terms covered in the text.
- *Study questions* are general questions that represent all the material covered in the text.
- *E-media* are web-based resources that pertain to the material covered in the chapter.
- *Bibliographies* are additional published resources for further study.

NOTE TO STUDENTS

As the field of physical activity and public health expands, an increasing number of job opportunities will be available for those who achieve the core competencies as endorsed by the National Society of Physical Activity Practitioners, established in

2006 (www.nspapph.org). Coursework that covers concepts of physical activity and public health will help future graduates in diverse employment settings such as public health and health care, business and industry, the nonprofit sector, education, mass media, urban planning and architecture, and parks and recreation. University students in majors and minors such as kinesiology, athletic training, physical therapy, medicine, nursing, and nutrition, as well as trainers in public services (fire, police, and military), rehabilitation specialists, and wellness instructors will find a natural connection between their professional duties and the need for promotion of physical activity and public health to colleagues and communities.

NOTE TO INSTRUCTORS

This text is targeted to students in exercise science or public health programs who are enrolled in elective courses that expand their understanding beyond what is taught in traditional core courses. The 2008 *Physical Activity Guidelines for Americans* (www.health.gov/PAGuidelines), the accompanying Physical Activity Guidelines Advisory Committee Report (www.health.gov/PAGuidelines/committeereport.aspx), and the CDC's *Guide to Community Preventive Services* (www.thecommunityguide.org) are valuable resources that provide much of the framework for the development of this text.

The following free ancillaries are also available to instructors who adopt this textbook:

- The **instructor guide** includes syllabus suggestions, teaching tips, and sample class assignments.
- The **test package** includes over 300 questions, including multiple choice, true-false, and fill-in-the-blank questions. The test package can be downloaded in multiple formats depending on your teaching needs, and can also be modified to include test questions that you create.
- The **image bank** includes all of the figures and tables from the text. You can use these items to create your own Power Point presentations, handouts, or other class materials.

These resources can be accessed at www.HumanKinetics.com/FoundationsOfPhysicalActivityAndPublicHealth. The authors, who have taught courses in physical activity and public health, have helped develop all of the ancillary materials.

We trust that *Foundations of Physical Activity and Public Health* will allow you to develop courses that inspire students to pursue careers in physical activity and public health.

eBook
available at
HumanKinetics.com

ACKNOWLEDGMENTS

Because life is a journey with many encounters that continually make us who we are, it is nearly impossible to acknowledge all those who have influenced and taught me over the years. Several people do stand out, however. Thom McCurdy and Louis E. Burnett Jr. sparked and fed my early interest in science. Caroline A. Macera introduced me to epidemiology and public health. Milton Z. Nichaman made me an epidemiologist. Steven N. Blair helped me tremendously by showing me how it all fit together and being the role model that we all should have and be. Thanks to each of these mentors who have helped to shape my thinking.

My wife, Ann, has been with me throughout the process and has seen my challenges as no one else can see them. My parents, Harold W. Kohl Jr. and Rose Ann Kohl, gave me every possible advantage and pushed me to challenge myself every day. Virginia Michelli assisted me throughout the process. This project would not have happened without the influence each has had on me.

—HWK

I thank my parents, Bob and Louise Murray, for being role models for active living and for supporting my academic pursuits. I want to also thank Karen Mitchell for encouraging my writing efforts and Bill and Ann Kohl for their friendship and wit, which made the whole process even more worthwhile.

—TDM

We acknowledge Geoffrey P. Whitfield, MS, RCEP, and two anonymous reviewers for their time and comments, which made this text more focused. Their contributions are sincerely appreciated. Mariya Grygorenko provided much needed editorial assistance. At Human Kinetics, several people contributed the right blend of patience, prodding, and talent to help bring this project to completion. Myles Schrag, Judy Park, and Brendan Shea in particular were most helpful and a pleasure to work with.

CONTENTS

PREFACE ix

ACKNOWLEDGMENTS xiii

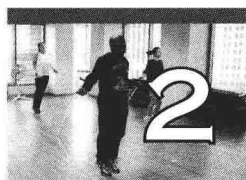
PART I

INTRODUCTION TO PHYSICAL ACTIVITY AND PUBLIC HEALTH. 1



FUNDAMENTALS OF PUBLIC HEALTH 3

- Defining Moments in Public Health 4
- Areas of Specialization in Public Health 6
- Core Functions of Public Health 11
- Public Health Law 12



FUNDAMENTALS OF KINESIOLOGY 17

- Kinesiology Disciplines and Exercise Training 20
- Principles of Exercise Training, Prescription, and Planning 22
- Applying Physical Activity and Exercise Training Principles 31
- Health and Fitness Benefits of Physical Activity
and Exercise 37



INTEGRATING PUBLIC HEALTH AND PHYSICAL ACTIVITY. . . 43

- History of Physical Activity and Public Health 44
- Role of Physical Activity in Chronic Disease Development 46
- From Science to Practice and Back 47
- Promoting Physical Activity for Health 50
- Practitioners of Physical Activity in Public Health 51



MEASURING PHYSICAL ACTIVITY 55

- Importance of Fitness Assessments 56
- Laboratory Measures of Energy Expenditure 56
- Electronic Measurements to Estimate Energy Expenditure 58
- Direct Observation Techniques 60
- Self-Report Instruments 61
- Surveillance in Populations 63

PART II**HEALTH EFFECTS OF EXERCISE
AND PHYSICAL ACTIVITY 71****CARDIORESPIRATORY AND METABOLIC HEALTH 73**

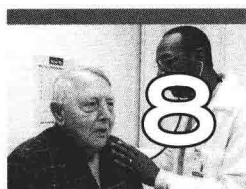
Prevalence of Cardiovascular Disease	76
Risk Factors for Cardiovascular Disease	76
Kinesiology and Cardiorespiratory Health	77
Cardiorespiratory Fitness Assessments	81
General Recommendations for Cardiorespiratory Health	82
Prevalence and Economic Costs of Metabolic Disease	86
Metabolic Disease Risk Factors	86
Kinesiology and Metabolic Health.	87
Common Tests of Metabolic Function	88
General Recommendations for Metabolic Health	89

**OVERWEIGHT AND OBESITY 95**

Caloric Balance	100
Prevalence of Obesity and Overweight and Associated Health Consequences.	101
Obesity and Overweight Risk Factors	104
Obesity and Overweight Challenges.	104
Kinesiology and Body Weight.	106
Common Assessments of Obesity and Overweight	106
Physical Activity Guidelines for a Healthy Weight	110

**MUSCULOSKELETAL AND FUNCTIONAL HEALTH 117**

Prevalence of Musculoskeletal Disorders and Related Health Challenges	118
Risk Factors Associated With Musculoskeletal Disorders and Associated Health Challenges.	119
Kinesiology and Musculoskeletal Health	121
Common Tests of Musculoskeletal Fitness or Function	124
Physical Activity and Musculoskeletal Health.	127
Functional Health	131
Risk Factors for Poor Functional Health	132
Common Tests of Functional Health	133
Fitness Recommendations for Functional Health.	133



CANCERS 139

- Prevalence of Cancers 140
- Cancer Risk Factors 142
- Kinesiology and Cancers 143
- Physical Activity Among Cancer Survivors 146
- Physical Activity Guidelines for Cancer Prevention 149



MENTAL HEALTH 153

- Prevalence and Economic Costs of Mental Health Disorders 154
- Common Mental Health Disorders 155
- Risk Factors Associated With Mental Health Disorders 156
- Physical Activity, Exercise, and Mental Health 157
- Exercise, Physical Activity, and Brain Function 159
- Physical Activity Guidelines for Mental Health 160

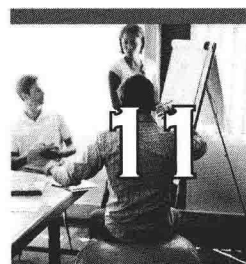


HEALTH RISKS OF EXERCISE AND PHYSICAL ACTIVITY . . 167

- Musculoskeletal Injuries 168
- Kinesiology and Musculoskeletal Injuries 171
- Sudden Adverse Cardiac Events 173

PART III

STRATEGIES FOR EFFECTIVE PHYSICAL ACTIVITY PROMOTION 179



INFORMATIONAL APPROACHES FOR PROMOTING PHYSICAL ACTIVITY 181

- Understanding the Community Guide 182
- Rationale for Informational Approaches 183



SCHOOL-BASED APPROACHES TO PROMOTING PHYSICAL ACTIVITY 195

- Rationale for School-Based Physical Activity Programs 196
- Kinesiology and Physical Activity Outcomes for Youth 198
- School-Based Physical Activity and Physical Fitness Assessments of Youth . . . 200
- Physical Activity in Children and Adolescents 200
- School-Based Physical Education. 203
- Developmental Considerations for Physical Activity in Youth 205



BEHAVIORAL AND SOCIAL APPROACHES TO PROMOTING PHYSICAL ACTIVITY 211

- Behavioral Theories and Theoretical Models of Behavior Change. 212
- Social Support for Health Behavior Change 215
- Individually Adapted Health Behavior Change Programs 217
- Social Support Interventions in Community Settings 220



ENVIRONMENTAL AND POLICY APPROACHES TO PROMOTING PHYSICAL ACTIVITY 227

- Access 229
- Urban Design and Land Use Policies 230
- Measuring the Built and Physical Environment 234
- Physical Activity Policy 235



PROGRAM AND POLICY EVALUATION FOR PHYSICAL ACTIVITY AND PUBLIC HEALTH 241

- Ways to Measure Program and Policy Effectiveness 244
- Logic Models for Physical Activity Promotion and Policies. 247
- Evaluation Designs. 251
- Data Collection and Analysis. 251
- Publishing and Communicating Results 253



PARTNERSHIP DEVELOPMENT AND ADVOCACY 257

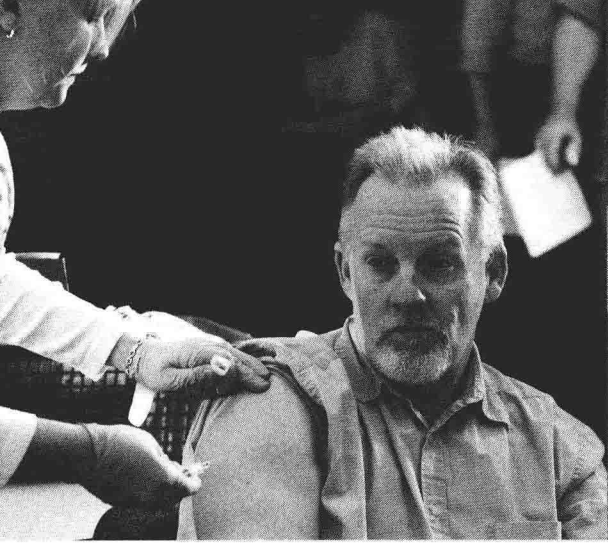
- Key Factors in Building Partnerships 259
- Strategies for Physical Activity Advocacy. 262



© Photodisc

PART I

INTRODUCTION TO PHYSICAL ACTIVITY AND PUBLIC HEALTH



FUNDAMENTALS OF PUBLIC HEALTH

OBJECTIVES

After completing this chapter, you should be able to discuss the following:

- » The definition and history of public health
- » How public health has become specialized and the five main pillars of public health
- » The five main principles that guide health promotion and health education efforts in public health
- » The 10 essential functions that support the core services of public health
- » Why public health policy is often linked to legal and regulatory systems
- » The emerging physical activity specialization in public health

OPENING QUESTIONS

What comes to mind when you read the words *public health*?

Screening children for nutritional deficiencies?

- » Quarantine practices to isolate a person with tuberculosis to prevent an outbreak of the disease?
- » Disaster responses to prevent disease transmission during and after a hurricane or earthquake?
- » Prenatal education for expectant mothers?
- » Promotion of physical activity to lower the burden of chronic, noncommunicable diseases such as heart disease and diabetes mellitus?

If you answered yes to any of these questions, you are correct. Public health is all this and more.

Public health is a field that encompasses many disciplines in an effort to promote and protect health and prevent disease and disability in defined populations and communities. Although medicine and medical training are integral to public health, particularly in understanding the mechanisms of disease transmission, medicine is more interested in the treatment of and cures for diseases and disabilities in individuals. The key difference between public health and medicine is that public health traditionally has focused less on individuals and treatment and more on populations and prevention.

Clearly, then, public health should be focused on problems that affect, or could affect, a substantial portion of the population. For this reason, rare diseases and disabilities and seemingly random health events are often less of a concern to public health than problems that may affect many people in a population. This is not to say that such situations are not important, particularly to the people afflicted, but rather, that the focus of public health is on the health of the population as a whole. Overall, the health of a population is rarely improved by focusing only on rare diseases and health problems that affect the few.

This first chapter offers an overview of the principles and key areas of public health and describes the fundamental services of public health. Happily, public health has grown far beyond its origins and has allowed populations to thrive in the face of new and emerging health problems.

DEFINING MOMENTS IN PUBLIC HEALTH

Although a complete treatment of the history of public health is beyond the scope of this chapter (it could, and does, fill whole books), an understanding of some defining moments in public health is instructive. This understanding helps place the emergence of physical activity and public health as a separate discipline within public health in context. Winkelstein (2011) offers a more complete treatment of the history and evolution of public health.

Although disease and **epidemics** have occurred for thousands of years, the earliest roots of organized public health emerged in the mid-14th century. At the time, the Black Death (bubonic plague) ravaged Europe, killing an estimated 25% of the population. As we know now, the disease was tied to the black rat, the rat flea (*Xenopsylla cheopis*) that lived on the blood of the black rat, and the bacterium *Pasteurella pestis* that helped the flea to seek out additional food by biting warm-blooded humans. At the time, however, an understanding of the germ theory of infection and disease (i.e., that microorganisms are responsible for sickness and not simply “bad air” or other nonbiological reasons) was still 400 to 500 years in the future. Advances in transportation (shipping) around Europe and the Middle East spread the disease to other geographic areas. Although no one knew when or how the disease would strike, public health was advanced