THE NUTRITION SOCIETY TEXTBOOK SERIES

Public Health Nutrition

Second Edition

Edited by
Judith L Buttriss, Ailsa A Welch,
John M Kearney and Susan A Lanham-New

WILEY Blackwell

Public Health Nutrition

The Nutrition Society Textbook Series

Now widely adopted in courses throughout the world, the prestigious Nutrition Society Textbook Series provides students with both specific scientific information and appropriate context.

These groundbreaking titles:

- Provide students with the required scientific basics of nutrition in the context of a systems and health approach
- Enable teachers and students to explore the core principles of nutrition, to apply these throughout their training, and to foster critical thinking at all times
- Are fully peer reviewed, to ensure completeness and clarity of content, as well as to ensure that each book takes a global perspective.

Nutrition Research Methodologies
Edited by Lovegrove, Hodson, Sharma & Lanham-New
March 2015
ISBN: 978-1-118-55467-8

***Clinical Nutrition*, 2nd Edition**
Edited by Elia, Ljungqvist, Stratton & Lanham-New
January 2013
ISBN: 978-1-4051-6810-6

Sport and Exercise Nutrition
Edited by Lanham-New, Stear, Shirreffs & Collins
October 2011
ISBN: 978-1-4443-3468-5

***Nutrition and Metabolism*, 2nd Edition**
Edited by Lanham-New, MacDonald & Roche
November 2010
ISBN: 978-1-4051-6808-3

***Introduction to Human Nutrition*, 2nd Edition**
Edited by Gibney, Lanham-New, Cassidy & Vorster
March 2009
ISBN: 978-1-4051-6807-6

Public Health Nutrition

Second Edition

Edited on behalf of The Nutrition Society by

Professor Judith L Buttriss
Director General, British Nutrition Foundation

Dr Ailsa A Welch
Reader in Nutritional Epidemiology, University of East Anglia

Dr John M Kearney
Lecturer, Epidemiology, Dublin Institute of Technology

Editor-in-Chief

Professor Susan A Lanham-New
Head of the Department of Nutritional Sciences, University of Surrey

WILEY

THE NUTRITION SOCIETY
Advancing Nutritional Science

This edition first published 2018 © 2018 by The Nutrition Society.

Edition History 1e © The Nutrition Society 2004.

Registered office: John Wiley & Sons, Ltd, The Atrium, Southern Gate, Chichester, West Sussex, PO19 8SQ, UK
Editorial offices: 9600 Garsington Road, Oxford, OX4 2DQ, UK
The Atrium, Southern Gate, Chichester, West Sussex, PO19 8SQ, UK
1606 Golden Aspen Drive, Suites 103 and 104, Ames, Iowa 50010, USA

For details of our global editorial offices, for customer services and for information about how to apply for permission to reuse the copyright material in this book please see our website at www.wiley.com/wiley-blackwell

Library of Congress Cataloging-in-Publication Data

Names: Buttriss, Judith L, editor. | Welch, Ailsa A, editor. | Kearney, John M., editor. | Lanham-New, Susan A, Editor-in-Chief. | The Nutrition Society (Great Britain), Issuing Body.
Title: Public Health Nutrition / edited on behalf of The Nutrition Society by Judith L. Buttriss, Ailsa A. Welch, John M. Kearney, Susan A. Lanham-New.
Other titles: Public Health Nutrition (The Nutrition Society (Great Britain))
Description: Second edition. | Chichester, West Sussex, UK ; Ames, Iowa, USA : John Wiley & Sons, Inc., 2017. | Includes bibliographical references and index.
Identifiers: LCCN 2016056644| ISBN 9781118660973 (paper) | ISBN 9781118660935 (Adobe PDF) | ISBN 9781118660966 (epub)
Subjects: | MESH: Nutritional Physiological Phenomena | Dietetics | Public Health
Classification: LCC RA645.N87 | NLM QU 145 | DDC 616.3/9—dc23 LC record available at https://lccn.loc.gov/2016056644

A catalogue record for this book is available from the British Library.

Wiley also publishes its books in a variety of electronic formats. Some content that appears in print may not be available in electronic books.

Cover image: © skystardream/iStockphoto

Set in 9.5/11pt MinionPro-Regular by Thomson Digital, Noida, India

10 9 8 7 6 5 4 3 2 1

Contents

Contributors

Professor Peter J Aggett
Lancaster University
UK

Dr Sarah C Bath
University of Surrey
UK

Bridget Benelam
British Nutrition Foundation
UK

Dr Francesco Branca
World Health Organization
Switzerland

Professor Eric J Brunner
University College London
UK

Dr Thomas Burgoine
University of Cambridge
UK

Professor Judith L Buttriss
British Nutrition Foundation
UK

Professor Janet E Cade
University of Leeds
UK

Dr U. Ruth Charrondiere
Food and Agriculture Organization of the United Nations
Italy

Dr Clare A Corish
University College Dublin
Ireland

Dr Andrea L Darling
University of Surrey
UK

Johanna T Dwyer
Tufts University
USA

Professor Ulf Ekelund
Norwegian School of Sport Sciences (NIH)
Norway

Professor Basma Ellahi
University of Chester
UK

Professor Paul Elliott
Imperial College London
UK

Cassandra H Ellis
The Nutrition Society
UK

Dr Charlotte EL Evans
University of Leeds
UK

Paul Finglas
Institute of Food Research
UK

Dr Emma Foster
Newcastle University
UK

Professor Kenneth R. Fox
University of Bristol
UK

Dr Christine Furber
The University of Manchester
UK

Jenny Gillespie
NHS Tayside
UK

Dr Bjørge H Hansen
Norwegian School of Sport Sciences (NIH)
Norway

Dr Richard PG Hayhoe
University of East Anglia
UK

Dr Anja Heilmann
University College London
UK

Dr Jayne Hutchinson
University of Leeds
UK

Elizabeth J Johnson
Tufts University
USA

Ashley T LaBrier
Tufts University
USA

Dr Amelia A Lake
Durham University
UK

Professor Susan A Lanham-New
University of Surrey
UK

Professor Alison M Lennox
University of Surrey
UK

Professor H David McCarthy
London Metropolitan University
UK

Professor Helene McNulty
Ulster University
UK

Dr Tracey A Mills
The University of Manchester
UK

Dr Emily Mohn
Tufts University
USA

Dr Farah Naja
American University of Beirut
Lebanon

Dr Lara Nasreddine
American University of Beirut
Lebanon

Dr Anne P Nugent
University College Dublin
Ireland

Dr Marga Ocke
National Institute for Public Health and the Environment
Netherlands

Dr Linda M Oude Griep
Imperial College London
UK

Jenny Plumb
Institute of Food Research
UK

Professor Margaret P Rayman
University of Surrey
UK

Mark Roe
Institute of Food Research
UK

Professor Peter J Rogers
University of Bristol
UK

Professor Tom Sanders
Kings College London
UK

Dr Paul A Sharp
Kings College London
UK

Dr Debbie M Smith
The University of Manchester
UK

Dr Sara Stanner
British Nutrition Foundation
UK

Dr Laura Stewart
NHS Tayside
UK

Professor Janice L Thompson
University of Birmingham
UK

Professor Tim G Townshend
Newcastle University
UK

Professor Richard G Watt
University College London
UK

Dr Elisabeth Weichselbaum
Nutrition Science and Consultancy
New Zealand

Dr Ailsa A Welch
University of East Anglia
UK

Dr Louise R Wilson
University of Surrey
UK

Professor Martin Wiseman
World Cancer Research Fund & University of Southampton
UK

Taryn Young
NHS Tayside
UK

BUCKINGHAM PALACE

As Patron of the British Nutrition Foundation I am pleased to contribute the Foreword for this comprehensive new edition of a popular textbook on Public Health Nutrition. Much has changed in the world of nutrition since the first edition was published in 2004, especially through confusing headlines and specialist research that seemed to contradict each other. The aim of the editorial team for the second edition, led by Professor Judith Buttriss from the British Nutrition Foundation, has been to bring the book up to date and, at the same time, to meet the requirements of students of nutrition and practitioners, as well as try to balance all that information. The book provides the reader with a comprehensive series of chapters in five themed sections, covering basic principles through to practical application of public health nutrition in local, national and international settings, and its translation into policy.

The Nutrition Society textbook series, first established by Professor Michael Gibney in 1998 and now under the direction of the second Editor-in-Chief, Professor Susan Lanham-New, continues to be an extraordinarily successful venture for the Society. This series of human nutrition textbooks is designed for use worldwide and this has been achieved by translating the series into many different languages including Spanish, Greek and Portuguese. The popularity of the textbooks is a tribute to the quality of the authorship and the value placed on them, both in the UK and Worldwide, as a core educational tool. I am sure this textbook will make a very valuable contribution to the Nutrition debate. Perhaps I might suggest a strapline: all things in moderation!

Preface

I am absolutely delighted in my capacity as Editor-in-Chief (E-i-C) of the Nutrition Society (NS) Textbook Series to introduce the Second Edition of *Public Health Nutrition*. So much planning and hard work has gone into producing this Second Edition, following a most successful production of *Public Health Nutrition* First Edition. We owe a great deal of thanks to Professor Barrie Margetts, Professor Lenore Arab and Dr John Kearney for their original work on this important book in the NS Textbook Series.

Public Health Nutrition 2nd Edition *(*PHN2e*)* has been led superbly by Professor Judith Buttriss (Director General, British Nutrition Foundation) as Senior Editor of the book, and her Editorial Team in the name of Dr Ailsa Welch (University of East Anglia) and Dr John Kearney (Dublin Institute of Technology). They have meticulously planned out the details of the chapters and managed to secure the world-leaders in the field to contribute key chapters. Professor Buttriss is a most inspirational leader, and the team have complemented one another admirably with their expertise and knowledge in the field, as well as providing great continuity from the First Edition. How indebted we are to all the contributors for making the book such a comprehensive review and we are absolutely thrilled, as Professor Buttriss outlines in her Introductory Chapter, to have so many global experts who have written chapters to make PHN2e a complete review of this key area.

PHN2e is intended for those with an interest in nutritional science whether they are nutritionists, food scientists, dietitians, medics, nursing staff or other allied health professionals. We hope that both undergraduate and postgraduate students will find the book of great help with their respective studies and that the book will really put public health nutrition as a *discipline* into context.

PHN2e comprises of a total 29 chapters; commencing with a detailed overview of the book structure and then a focus of five sections; namely: 1) Public Health Nutrition Tools; 2) Current State of Evidence; 3) Diet and Disease; 4) Environmental Factors and 5) Public Health Nutrition Strategies and Approaches, with each chapter providing a key summary of the take home messages.

We are extremely honoured and most sincerely grateful that the Foreword for PHE2e has been written by Her Royal Highness The Princess Royal, who has a great depth of knowledge in the field and who speaks with authority on key issues in Public health Nutrition. It gives us great confidence in this textbook to have such a Royal seal of approval.

The first and second textbooks in the Series: *Introduction to Human Nutrition* (IHN) and *Nutrition & Metabolism* (N&M), are now out in 2nd Edition and sales continue to go extremely well, with third editions now fully under-preparation. Sales of Professor Marinos Elia *et al*'s *Clinical Nutrition* 2nd Edition (CN2e - fourth textbook) continue to sell apace and our fifth textbook in the Series, *Sport and Exercise Nutrition* 1st Edition (SEN1e) has surpassed all expectations. Our sixth textbook, *Nutrition Research Methodology* 1st Edition (NRM1e) led by Professor Julie Lovegrove *et al* provides great complementarity to PHN2e, and the Series, and is proving to be an excellent textbook in its own right.

We are most grateful to the following individuals for their support and most generous Forewords in SEN1e, CN2e and NRM1e respectively; namely - Professor Richard Budgett OBE, Chief Medical Officer for the London 2012 Olympic and Paralympic Games and now Medical and Scientific Director at the International Olympic Committee (IOC) based in Lausanne, Switzerland; Dame Sally Davies, Chief Medical Officer (CMO) for England, and the UK Government's Principal Medical Adviser; Professor Lord John Krebs, Principal, Jesus College, University of Oxford and our first Chairman of the UK Food Standards Agency.

The Society is most grateful to the textbook publishers, Wiley-Blackwell for their continued help with the production of the textbook and in particular, James Watson, Jennifer Seward and Francesca Giovannetti. We would also like to thank Garima Singh from Thomson Digital for her great help with PHN2e finalisation. In addition, I would like to acknowledge formally my great personal appreciation to Professor G.Q. Max Lu AO, FRSC, FIChemE, Vice-Chancellor of the University of Surrey, and Professor David Blackbourn FRSB, Head of the School of Bioscience and Medicine, University of Surrey, for their respective great encouragement of the nutritional sciences field in general, and the Textbook Series production in particular.

Sincerest appreciation indeed to the Nutrition Society past-Presidents, Professor Sean J.J. Strain OBE (Ulster University) and Professor Catherine Geissler (King's College London) and current-President, Professor Philip Calder (University of Southampton) for their belief in the Textbook Series. With special thanks to past-Honorary Publications Officer, Professor David Bender (University College London), and present-Honorary Publications Officer Professor Paul

Trayhurn (University of Liverpool) for being such tremendous sounding boards for the Textbook Series. I am hugely grateful for their wise counsel. And finally a very big thank you indeed to Cassandra Ellis, Assistant Editor, NS Textbook Series, for her incredibly important contribution to the development of the Series.

Finally, as I always write and absolutely do not forget (ever!), the Series is indebted to the forward thinking focus that Professor Michael Gibney (University College Dublin) had at that time of the Textbook Series development. It remains such a tremendous privilege for me to continue to follow in his footsteps as the second E-i-C.

I really hope that you will find the textbook a great resource of information and inspiration . . . please enjoy, and with so many grateful thanks to all those who made it happen!

With my warmest of wishes indeed

Professor Susan A Lanham-New RNutr, FAfN FRSB
E-i-C, Nutrition Society Textbook Series and
Head, Department of Nutritional Sciences
School of Biosciences and Medicine,
Faculty of Health and Medical Sciences
University of Surrey

Introduction

Much has changed in the 12 years since the launch of the first edition of *Public Health Nutrition*. With an explosion of research in this area, changes in nutrition policy and food-related legislation, and shifts in population health, dietary patterns and the food supply, the second edition represents a complete rewrite. We are honoured to have so many global experts in public health nutrition (PHN) contributing to make this textbook a comprehensive review.

To ensure the second edition reflects the most recent knowledge and research, and meets the requirements of students and practitioners alike, an expert advisory group was consulted throughout the planning process. The group members, representing research, teaching and PHN practice, were asked to comment on the content and structure of the new edition, and to provide guidance on what they were looking for in a PHN resource.

The textbook not only introduces PHN concepts, it is also intended to support learning for students and to be a practical guide for health professionals and those working within public health. More generally, feedback highlighted the benefit of including case studies to illustrate the practical application of the evidence and how this translates to policy. Case studies have therefore been included throughout to support the evidence and to offer practical advice for those working within PHN.

The clear message throughout consultation was the importance of structure and flow through the textbook. To ensure a clear, concise structure, the 29 chapters have been divided into clearly defined sections covering five key areas of PHN.

Part One outlines PHN assessment tools. This provides an introduction to concepts in PHN, followed by an overview of dietary assessment methodology, anthropometry and physical activity measures, with a focus on contemporary measures using new technology as well as traditional methods. This part then outlines the importance of food composition data in nutrition research, food safety and food security, and discusses dietary guidelines.

Part Two moves on to considering the application of PHN tools in a review of the current evidence. It begins by outlining dietary patterns and how they are defined before discussing vitamins and minerals that are of particular concern due to prevalent deficiency. This part also examines nutrition through the lifecycle, from pre-conception to old age, considering the public health challenges and risk factors at each phase.

Part Three reviews the relationship between diet and disease. Beginning with the risks of obesity in pregnancy and childhood, chapters that follow discuss some of the comorbidities of obesity, cardiovascular disease and type 2 diabetes. The relationship between diet and cancer is also examined, with consideration to both the protective and the carcinogenic roles of dietary factors. The PHN challenges associated with bone and dental health are also reviewed, and the relationship between diet and mental health and cognitive function is explored.

Part Four looks at the impact of environmental factors on public health, starting with consideration of the effects that obesogenic environments have on diets and health. Also explored is how aspects such as advertising, health promotion, food reformulation and food legislation can affect dietary behaviours.

Finally, Part Five outlines current public health strategies, policies and approaches. It begins broadly with a global perspective, before considering community strategies and engagement, how these strategies can be used to influence behaviour change, and the importance of culturally sensitive interventions and policies. The final chapters provides an evaluation of current policies and interventions and the social determinants of diet and health.

Judith L Buttriss

About the Companion Website

This book is accompanied by a companion website:

www.wiley.com/go/buttriss/publichealth

The website includes:

- Multiple choice questions
- Short answer questions
- Essay titles
- Further readings

Part One

Public Health Nutrition Tools

1
Introduction to Public Health Nutrition

Martin Wiseman

Key messages

- Nutrition is fundamental for life and health. The term 'nutrition' encompasses both biological and sociological aspects of how cells, tissues and organisms access the substrates and cofactors that are necessary for normal conception, growth, development and ageing.
- Public health nutrition refers to nutritional aspects of public health, which is the science and art of promoting and protecting health and well-being, preventing ill health and prolonging life through the organised efforts of society.
- The historical focus of public health nutrition has been on undernutrition, which is still a major problem across all levels of development. In less economically developed countries, it most commonly manifest as deficiencies of micronutrients as well as wasting and stunting (acute and chronic malnutrition) in childhood. In economically developed countries undernutrition is a common feature of ageing, though nutrition-related chronic noncommunicable diseases such as obesity, type 2 diabetes, cardiovascular disease and several common cancers predominate. Increasingly, as less economically developed countries undergo nutritional transition, they are experiencing a rising burden of these diseases, so that these are now the major nutrition-related disease burden globally.
- The characterisation of human nutrient requirements is a fundamental activity for public health nutrition, and their application in clinical or public health settings requires training and experience that marks professional nutritional practice.
- Effective public health nutrition requires three discrete functions
  - the acquisition, synthesis and dissemination of knowledge relating nutrition to health and disease;
  - surveillance programmes to detect potential nutritional problems across the life course among the population, and to monitor change;
  - evidence-informed policy development, implementation and evaluation.
- Public health nutrition policy relies on ensuring that people have the necessary information to make healthy choices around food and physical activity, as well as on ensuring that the environment in which they live is conducive to making those healthy choices. Policy makers need to balance the evidence for health need against economic and other socio-political factors in determining what action to take.

1.1 Public health and nutrition

Nutrition lies at the heart of health. Human life – from conception or even before, through fetal and childhood growth, development and maturation, to adult life and old age – creates a demand for energy and nutrients, and relies on their adequate provision, and on the body's metabolic capability to transform these substrates and cofactors into the multitude of chemicals needed by cells for normal structure and function, driven by their genetic endowment. Nutrition is the process by which cells, tissues, organs, people and populations achieve this. Poor nutrition leads to poor health; and poor health also often leads to poor nutrition.

Public health refers to those aspects of health that affect the population as a whole, their study and the services that aim to deliver it. Public health nutrition is where these two concerns – population health and nutrition – interact or overlap.

Public health is defined as 'The science and art of promoting and protecting health and well-being, preventing ill health and prolonging life through the organised efforts of society'.

Public Health Nutrition, Second Edition. Edited by Judith L Buttriss, Ailsa A Welch, John M Kearney and Susan A Lanham-New.

Companion website: www.wiley.com/go/buttriss/publichealth

It is worth elaborating on that concise definition, first to note the implicit recognition that the evidence (science) underpinning actions to promote or protect health may often be incomplete, and that professional judgement (art) is needed to interpret and apply it. This is no different in concept from the application of science in clinical care, where the demand for evidence-based practice exposes gaps in knowledge of how to manage the very variable presentations of individual patients, but does not paralyse clinical action. Second, it is important that prolongation of life is linked with the promotion of health and prevention of ill health, in order to avoid prolonged disability with ageing. The aim is to shorten the period of ill health (compression of morbidity) before death in old age. Third, public health needs to be organised. It is not a default, as can be seen in the many parts of the world where effective public health structures and systems do not exist, and where infant and maternal mortality are high, expectation of life is low, and infectious and increasingly non-communicable diseases are common, as was the case in now economically developed countries in the past. Finally, the responsibility to make efforts falls not only to the small group of people who are professionals in public health, but to society as a whole. This recognises that the determinants of health in populations have little to do with the health care system (which deals with the problems of failed health), and are mostly related to the wider environmental conditions in which people are conceived, born, grow, live, work and age. Public health is about creating environments that are conducive to health, and public health nutrition is about creating environments that are conducive to healthy nutrition.

1.2 History of nutrition in public health

The ancients regarded food and medicine as related aspects, and since the demonstration in the 18th century by James Lind that lime juice was effective in curing and preventing scurvy (even though the finding was initially ignored and later had to be rediscovered), it has been clear that the provision of appropriate quality and quantity of food is essential in securing people's health.

The importance of food for growth, development and health was apparent despite lack of knowledge of the biological processes involved. This ignorance of the detail of the body's nutritional demands and how different foods and diets can meet them meant that it was difficult to derive rational nutrition policies.

The UK offers a good illustration. In the UK during the First World War, disruption to food imports from abroad had a major impact on the food supply (see Table 1.1), but there was insufficient understanding of the nutritional consequences for a coherent political response to be mounted.

Table 1.1 When food imports were seriously disrupted in the First World War (WW1), limited nutrition knowledge meant that a coherent food policy was not possible and the food supply was adversely affected. In contrast, despite similar disruption to food imports in the Second World War (WW2), the application of the new nutritional science into effective policy ensured that the food supply was maintained and equitably distributed to secure the health of the population.

	WW1	WW2
Milk	−26%	+28%
Eggs	−40%	−6%
Meat	−27%	−21%
Vegetables	−9%	+34%

Source: Magee (1946). Reproduced with permission of BMJ Publishing Ltd.

Subsequently, the British population experienced food shortages, and malnutrition was a major problem. After the establishment of the Ministry of Health in 1919, food and nutrition were early targets for a more systematic approach to policy. In 1921 the Ministry published a report on 'Diet in Relation to Normal Nutrition' that identified the importance of so-called 'protective foods' – green leafy vegetables, milk and eggs – for healthy growth in children. This period coincided with the explosion of nutrition research into the accessory food factors (vitamins, minerals and trace elements) and the biological mechanisms for their effects – a discipline which spawned the new word 'biochemistry'. By the time of the Second World War, when there was a similar disruption as in the first war to the food imports on which the British food supply depended, nutritional science had progressed sufficiently for the Government to base its food policy on sound science. This policy, which involved public education with enhanced local food production and controls on the equitable distribution of food, led to quite different effects on the food supply (see Table 1.1), and its success to the British Ministries of Food and Health later receiving the prestigious Lasker Award for public health.

This period set the foundations for the essential elements of food and nutrition policy into the future. The key aspects are

- a transparent mechanism for the provision of scientific nutrition advice to government;
- reliable means for monitoring diet and nutrition status among the population;
- effective means of developing and evaluating policies to assure the quality and quantity of the food supply, and the nutritional health of the population.

The most prominent aspect of nutritional advice was the establishment by groups of experts of so-called recommended daily (or dietary) allowances. These set the amounts of essential nutrients needed to be consumed by populations to minimise risk of deficiencies, based on the growing science. These reports, published in the UK in the same series as the 1921 report for the Ministry of Health, have now been supplanted in most countries, following the UK 1991 report on dietary reference values, by attempts to describe the estimated range of dietary requirements for different nutrients among populations, including the balance of macronutrients considered desirable to reduce risk of chronic disease.

The establishment in Britain in 1940 of the National Food Survey was the forerunner of a systematic programme of diet and nutrition surveys which characterise the food and drink consumption of the population from childhood to old age, as well as their nutrition status in terms of anthropometry and biochemical measurements of blood and urine, and relevant physiological measures such as blood pressure. Such food and health monitoring systems play an essential role in the detection of nutritional problems in the population, tracking their development, and evaluating the effectiveness of policies to address them.

The success of the wartime food policy in the UK may in part be ascribed to the possibility of applying stringent controls and restrictions on the national diet due to the national emergency, as well as the coincidentally high levels of physical activity that were prevalent at the time. However, such restrictive approaches, though effective, are unlikely to find favour beyond the stringent circumstances of such an emergency, and a critical issue for policy makers is to find effective means of promoting healthy nutrition without inappropriate interference with people's freedom to choose how they live. This dilemma has been addressed by various commentators, including the Nuffield Council on Bioethics.

1.3 Nutrition and public health in different parts of the world

For the majority of the 20th century, nutrition policy in industrialised countries was directed to the elimination of classic micronutrient deficiency diseases such as scurvy and rickets, which were major scourges in particular among the least affluent in society. In less economically developed countries, gross malnutrition with wasting and stunting of children, and high levels of maternal and child mortality, as well as specific nutrient deficiencies, remain common, mirroring the situation of the previous century in industrialised countries.

During the latter part of the 20th century and in the 21st century, the prominence in economically developed countries of deficiency diseases diminished with better access for all to a wide variety of foods, and effective food fortification policies. However, this was replaced by a growing burden of chronic non-communicable disease, at first cardiovascular disease, but increasingly cancers, obesity and diabetes. At the same time, some micronutrient deficiencies – in particular rickets – began to re-emerge, while undernutrition in the ageing population has become an important concern, sometimes simply due to poor dietary intake (with low lean mass and activity levels), and sometimes consequent to disease.

In less economically developed countries, the problems of malnutrition with stunting and wasting continue to dominate, but as the populations undergo an economic transition from rural to more urbanised ways of life, they also undergo a nutrition transition so that rates of obesity, and other chronic non-communicable diseases, are also rising, creating the so-called double burden (of over– and undernutrition). In places such as Thailand and Chile, which have had tangible success in reducing undernutrition, this has been at the cost of a rise in prevalence of overweight and obesity.

Clearly, malnutrition in all its forms affects all parts of the globe, though its segmentation within society varies.

1.4 Current role of nutrition in public health

Socio-demographic changes are affecting many parts of the globe. In most countries people are living longer, while economic development is also driving increased urbanisation, with rapid and profound changes in ways of life. In more affluent countries, average smoking rates are declining, while prevalence of overweight and obesity are increasing, and levels of physical activity have fallen. Traditional diets are being replaced by typical 'westernised' patterns, with more processed foods including fats, oils, refined starches and sugars, higher salt intake and a greater reliance on foods from animal as opposed to plant sources.

In less economically developed countries there is a rising burden of cardiovascular disease, and increasingly also the cancers more typical of affluent nations – breast, colorectal and prostate – related to nutritional factors, in place of the cancers caused by infections – liver, stomach and cervix. Lung cancer remains a scourge – though mostly of men – as smoking rates have not declined as in more affluent countries, and indeed are still rising in some.

In more affluent nations, rates of cardiovascular disease are declining, so that with increasing age the major non-communicable disease group is predicted to be

cancers, many of which are related to dietary patterns, body fatness and physical activity levels.

Meanwhile malnutrition – stunting and wasting in children, short stature in adulthood, as well as specific micronutrient deficiencies – remains prevalent, often within the same communities as increasing overweight and obesity. Even in richer countries, where food security is less of a problem, micronutrient deficiencies such as rickets remain persistent in vulnerable groups, and are possibly increasing.

1.5 Nutrition through the life course

Nutritional problems have always been recognised at all stages of the life course. Maternal overweight or obesity, or underweight, are known to influence the outcome of pregnancy both for the mother and the infant. Low birth weight remains a problem among low-income countries, and nutritional factors are key. Poor growth with wasting and stunting are classic nutritional problems of undernutrition, which remain prevalent in low income countries, while increasingly in high income countries obesity is becoming a serious problem in childhood. One consequence of the nutrition transition is the development of a cohort of people of short stature from undernutrition in childhood, but who then become overweight or obese; this combination carries enhanced risk for nutrition-related problems, in particular for maternal and fetal outcomes in pregnancy. Adolescence is a period of rapid growth and development, with increased demands for energy and nutrients, and so is a period of vulnerability to any constraint on supply, and this can be compounded by early pregnancy, which drives competing demands between mother and fetus. Micronutrient deficiencies remain prevalent where food supply is monotonous and insecure, emphasising the need for dietary diversity, while adult obesity with its attendant co-morbidities of diabetes, cardiovascular disease and some cancers is a major problem for high-income countries and increasingly so for middle– and even low-income countries. Undernutrition is also becoming an important cause of morbidity and mortality among older people.

There is growing recognition of the impact of nutrition not only in the immediate context, but as a determinant of future health. Non-communicable chronic diseases such as obesity, diabetes, cardiovascular disease and cancers result from the interaction of people's current exposures – their diet, activity levels and nutritional state – with their susceptibility. Susceptibility is partly determined by genetic endowment; however, it is now clear that early life events (in particular constraint of growth due to imbalance between the amount or quality of the demands for energy or nutrients, and their supply, from conception to adulthood) can have a profound impact on later risk of these conditions.

1.6 Principles of public health nutrition

Effective public health nutrition requires three discrete functions

- the acquisition, synthesis and dissemination of knowledge relating nutrition to health and disease;
- surveillance programmes to detect potential nutritional problems across the life course among the population, and to monitor change;
- evidence-informed policy development and implementation.

The primary prevention of disease relies on the identification of the causes of disease, so that they may be addressed. The identification of infectious causes has led to the development of vaccination and antibiotics, and of means to control their vectors, such as the mosquito for malaria. The identification of a deficiency of the essential nutrients allowed for dietary approaches to their prevention, and policies such as food fortification. For nutrition-related chronic non-communicable diseases, with multiple causes and highly variable susceptibility in the population, not only is the identification and characterisation of the pathways of causation complex, but equally the appropriate medical, public health or political response is often difficult to agree. Nevertheless, an analogous approach to these problems allows an open dialogue on how to address them.

It is essential that any approach relies on the whole body of scientific evidence. As in all health practice, this may be epidemiological information, clinical trial data or laboratory evidence, or less reliable forms. In clinical medicine, randomised controlled trials (RCTs) are rightly regarded as superior to other forms of investigation because of their ability to test relevant hypotheses with a robust design and avoid the problems of confounding that arise in epidemiological studies. However, for primary prevention of chronic non-communicable disease that manifests in adulthood but has roots in early life, and where the impact of environmental exposures takes decades, it is less clear that RCTs have net overall advantage. While well-designed and –executed RCTs have strong internal validity (they give a correct answer to the hypothesis tested), they often lack external validity (that is, they cannot test the right hypothesis) perhaps because they are not conducted in an appropriate population or use atypical exposures. For primary prevention, intelligent interrogation of the whole body of evidence is required to infer causation from observed associations. This can be aided by using accepted frameworks such as

that derived by Bradford Hill. Such synthetic approaches to the evidence can identify preferred patterns of diet or lifestyle likely to reduce disease and promote health.

Once such patterns are identified, it is important to explore to what extent they are present in the population, and in potentially vulnerable subgroups. For this reason, proactive nutritional surveillance of the population is a necessary component of rational public health nutrition. Such monitoring surveys may identify the prevalence of disease risk factors in the population such as obesity or physical inactivity, or of biological factors such as high blood pressure or disordered blood lipids. They also allow the impact of policy to be evaluated.

Vulnerable subgroups may be defined in several ways. They are often defined in terms of age, sex, ethnicity or socio-economic state. However, it is equally possible to conceive vulnerability from a biological perspective. Diet and health surveys allow the distribution of relevant variables (such as risk factors or markers of nutritional status) within the population to be calculated. Though one aim of policy is to shift the whole distribution of risk in a population in a beneficial direction, interest – aided by newer technologies – is increasingly being paid to exploring the variability itself. Such variability reflects individual characteristics that determine susceptibility (e.g. to disease), and characterising the risks of individuals *within* the population and their determinants (as well as the determinants of differential risk *between* populations, which may be different) is an increasing focus of attention. For example, fortification of staple foods with folic acid has been proposed (and in some countries implemented) to ensure adequate intake in women who become pregnant to reduce the risk of neural tube defects in their offspring. However, there are concerns that such broad exposure to fortified foods might lead to excessive intakes among those who already have high intakes, emphasising the need to consider the shape of the distribution of intake, and not only the average.

Finally, effective public health action requires the development of policies based on the evidence. Though seemingly obvious, much nutrition policy may nevertheless be based on preconceptions or ideological preferences. Because the evidence for effectiveness of policy is difficult to obtain by conventional medical models of investigation, policy needs first to identify the nutritional problems that need addressing; to develop policies based on the best evidence available (even if incomplete) and implement them in a way that can be evaluated to allow the policy to be continuously improved (that is, to develop evidence from the evaluation of policies in action). Because policy often involves politics, and the solution needs to embrace not only the health aspects but also socio-political considerations, tensions may arise in identifying the appropriate intervention or its degree. This aspect has been addressed by the Nuffield Council on Bioethics, which developed a 'ladder' of different degrees of intervention as a framework for consideration (Figure 1.1). While this ladder offers a valuable framework, it is predicated on relatively simple, single actions. This limits its practical use in public health, which has the characteristics of a complex system. Failure to recognise the inherent complexity in the determinants of people's behaviour may in part be responsible for the relatively modest effects observed from many more linear interventions, as well as unwillingness to adopt policies that are more restrictive.

The question arises as to who should take action. The definition of public health draws attention to the need for organised efforts of society. While it falls clearly to the health professions and politicians to take the lead in the organisation of society's efforts, it is clear that the roots of environmental exposures linked to health or disease fall far outside the ambit of health practice. The complex environmental determinants of people's behaviour are formed by the cumulated actions of all sectors of society, many of whom have no sense of their role or responsibility in public health. Yet, it is only by engaging with all sectors, and creating a synergy of action, that the environment will become conducive to the promotion of healthy long life for all. Much public health policy is driven by professional and other sectors, attempting to impose top-down change on people, while examples of success are often characterised by a groundswell of demand form the grassroots (bottom-up). Finding ways to engage with people through their own communities, and manage the interface between them (us) and more powerful sectors, is critical for lasting and substantive success.

1.7 Conclusions

Public health nutrition, like other health professions, relies on the application of incomplete evidence in biological, psychological and sociological spheres. It requires the engagement of parts of society that are outside traditional health sectors, and the capacity to identify, collect, synthesise and disseminate relevant information, and to use it effectively to influence important players from the public to politicians. Public health nutritionists have a lead responsibility in organising the efforts of all parts of society to create an environment conducive to good nutrition and health.

The range of options available to government and policy makers can be thought of as a ladder of interventions with progressive steps from individual freedom and responsibility, towards state intervention as one moves up the ladder. In considering which 'rung' is appropriate for a particular public health goal, the benefits to individuals and society should be weighed against the erosion of individual freedom. Economic costs and benefits would need be taken into account alongside health and societal benefits. The ladder of possible policy action is as follows:

Eliminate choice. Regulate in such a way as to entirely eliminate choice, for example through compulsory isolation of patients with infectious diseases.

Restrict cholce. Regulate in such a way as to restrict the options available to people with the aim of protecting them, for example removing unhealthy ingredients from foods, or unhealthy foods from shops or restaurants.

Guide choice through disincentives. Fiscal and other disincentives can be put in place to influence people not to pursue certain activities, for example through taxes on cigarettes, or by discouraging the use of cars in inner cities through charging schemes or limitations of parking spaces.

Guide choices through incentives. Regulations can be offered that guide choices by fiscal and other incentives, for example offering tax·breaks for the purchase of bicycles that are used as a means of travelling to work.

Guide choices through changing the default policy. For example, in a restaurant, instead of providing chips as a standard side dish (with healthier options available), menus could be changed to provide a more healthy option as standard (with chips as an option available).

Enable choice. Enable individuals to change their behaviours, for example by offering participation in an NHS 'stop smoking' programme, building cycle lanes, or providing free fruit in schools.

Provide information. Inform and educate the public, for example as part of campaigns to encourage people to walk more or eat five portions of fruit and vegetables per day.

Do nothing or simply monitor the current situation.

Figure 1.1 The intervention ladder. Source: Nuffield Council on Bioethics (2007). Reproduced with permission of Nuffield Council on Bioethics.

References

Magee, H.E. (1946) Application of nutrition to public health: some lessons of the war. *British Medical Journal*, **1**, 475–482.

Nuffield Council on Bioethics (2007) *Public Health: Ethical Issues*. Cambridge Publishers Ltd, Cambridge. http://nuffieldbioethics.org/wp-content/uploads/2014/07/Public-health-ethical-issues.pdf (accessed 23 November 2016).

2
Concepts and Definitions Used in Public Health Nutrition

Eric J Brunner and Ailsa A Welch

Key messages

- The main concepts and definitions used in public health are outlined.
- The nature of the evidence required to make decisions for public health nutrition is described, including issues of study design and interpretation.
- The issues of measurement error in the evidence that supports public health nutrition are discussed.
- The social determinants of diet and health are discussed.

2.1 Introduction

Public health nutrition has been defined as the science and art of preventing disease and promoting positive health by means of good nutrition. Public health nutrition, like medicine, is grounded in scientific knowledge, which is applied to a range of health-related problems and ambitions. Public health nutrition differs from clinical medicine, and clinical nutrition, in that its target is the group rather than the individual. This distinction is clear if we think about obesity: a clinical nutritionist would seek to help an individual obese child to lose weight, while a public health nutritionist would tend to work with groups of children either to lose weight or perhaps better to reduce the chance that any of them become obese. Public health nutrition is interdisciplinary in nature. The scope of knowledge and skills is wide (see Box 2.1 for examples) because the range of problems that public health nutrition can tackle is wide.

Nutritional epidemiology provides the evidence for policy and action in public health nutrition. The science base of public health nutrition continues to develop and expand, and workers in the field consider that the evidence we have now is incomplete. This situation is not an excuse for inaction, because there are many obvious problems of under– and overnutrition across the planet that need to be solved urgently. The reality is complicated. First, we cannot always wait for faultless evidence before calling for action. Second, public health is only one voice among many that strive to influence dietary habits. Powerful stakeholders produce a food environment with high availability of low-cost, energy-dense but nutrient-poor food and drink products. Third, socioeconomic inequalities in health – deprivation and disadvantage linked to poorer health right across the social hierarchy – are generated in part by social differences in dietary patterns which are themselves shaped by market forces. (In this context, the wider environment and dietary patterns are covered in more detail in Chapters 9 and 24.)

The imperfections in our understanding of the links between diet, disease and health mean that it is important for public health nutritionists to be aware of the methods and challenges in the research: how we know what we know and what produces the evidence to support their beliefs and practice. The vital topics of the nature of evidence and what counts as weak or strong evidence, the design of studies, and the important problem of measurement error (a defining characteristic of nutrition research) are outlined briefly in Sections 2.2, 2.3 and 2.4. Section 2.6 highlights a key distinction between risk assessment and risk management. Section 2.7 presents an outline of this social determinants perspective, and makes the case for its relevance to public health nutrition.

Public Health Nutrition, Second Edition. Edited by Judith L Buttriss, Ailsa A Welch, John M Kearney and Susan A Lanham-New.

Companion website: www.wiley.com/go/buttriss/publichealth

Box 2.1 Skills and knowledge in public health nutrition

Extending a foundation in nutrition, human science or food science
Public health (theory and practice)
Epidemiology and biostatistics
Nutritional epidemiology (dietary causes of disease or prevention of disease)
Behavioural and health promotion science
Nutritional assessment
Research methods

2.2 Nature of evidence

Two types of evidence provide direct support for rational practice in public health nutrition. The first answers the question, 'What is going wrong?' (That is, what the problem is and what the causes of that problem are.) The second answers the question, 'How can I best intervene?' The first type of evidence tells us about the contribution of nutritional factors for causation of diseases of public health importance; for example, that a high habitual intake of saturated fatty acids increases the risk of heart attack. Such evidence generally applies to everyone, across time and place. Because of the widespread significance of nutritional effects on health it is important to make the distinction between claims which are supported by scientific studies and those based merely on enthusiasm or vested interests (Box 2.2). Such knowledge needs to be placed in a context: in the population of interest, what proportions of children and adults have high (or low) intakes? The second type of evidence helps us to identify effective ways to reduce the problem. There are often a number of different modes of intervention that could be employed. A medical model might involve dietary advice to adults when they visit their doctor. A social marketing model might involve an advertising campaign. A fiscal model might centre on a tax on saturated fat. Some interventions may work well in one country and badly in another. Some interventions may be introduced in one year and scrapped the next, as was the case with the fat tax in Denmark in 2011 (Bodker *et al.*, 2015).

Box 2.2 Eminence-based nutrition: Linus Pauling and vitamin C

Linus Pauling was awarded the 1954 Nobel Prize in Chemistry and was one of the youngest people to be elected to the National Academy of Sciences. In his later years, Pauling became obsessed with the idea that megadose vitamin C (1–3 g, compared with the US adult recommended daily allowance of about 80 mg) would prevent the common cold and cure cancer. Pauling's fame as a scientist and the food supplement industry promotion led more than a third of American adults to use megadose vitamin C supplements in the 1970s. Many good quality trials have since shown that these health claims have no basis in fact, and similarly that megadose vitamin C does not prevent heart disease or delay mortality (Offit, 2013).

2.3 Methods and study design

It is clear that a wide spectrum of research methods sits behind the different strands of evidence. Details of the types of study design available and of their advantages and disadvantages are given in Table 2.1.

Nutritional epidemiology is the science providing the basic knowledge about the dietary causes of disease. Studies are typically large, with hundreds or thousands of participants followed for a decade or more. Such necessarily expensive longitudinal cohort studies observe the real world as opposed to laboratory-based phenomena, with the aim of testing hypotheses about diet, health and disease. The principle is simple. Individuals are ranked according to their baseline intake of the food or nutrient of interest. The hypothesis is tested by examining the strength of the association between the level of dietary exposure and the health outcome of interest. If there is an association, the rate of disease occurrence will change as intake increases. The design, execution and analysis of such studies is challenging. The challenges include measurement of complex dietary behaviour, recruitment of a large sample of study participants and their retention until sufficient outcomes (e.g. deaths, cases of disease) have occurred, and separating out the effects of numerous dietary and non-dietary exposures once the data have been collected.

At this point we must note that 'association is not the same as cause'. Observational studies suffer from a specific conceptual weakness. Exposure status, which is to say levels of dietary intakes, is self-selected. Because unhealthy (or healthy) behaviours tend to cluster in the same individual, it may be difficult to know which aspects of dietary and non-dietary behaviour are exerting causal effects, even if there is supporting evidence from laboratory or animal studies about the biological plausibility of the causal effect in question. This is the problem of confounding: the confusion of the effect of one exposure with that of one or more other exposures on the disease outcome of interest.

A confounder is a 'third' factor such as age (where exposure and outcome are the first and second factors) which is associated with the exposure and also is a risk factor for the outcome. For instance, if the question of

Table 2.1 Types of study design that provide supporting evidence for public health nutrition and their advantages and disadvantages.

Study design	Name/ alternative name	Description	Advantages	Disadvantages
Intervention study	Randomised controlled trial/ clinical trial	Comparison of event rates, behaviour and risk factor changes in individuals or groups of people exposed to an intervention (e.g. dietary advice) with a control or comparison group	Low probability of selection bias, recall bias, confounding Pilot policy change by comparing effect of new and old policies Demonstrate effectiveness	Risks of bias due to loss to follow up High time and cost requirements Educational and behavioural interventions are difficult to conceal. Resulting 'contamination' distorts observed effect sizes
Cohort study	Prospective study Follow-up study Longitudinal study	Measurement of exposures (e.g. dietary intake) with follow up over time for incident events/risk factor status Studies relationships between exposures and outcomes	Prospective study avoids recall bias Can study multiple exposures Obtain direct measures of incident disease/outcomes Observe time sequences and relationships Control for possible multiple confounders	Risks of bias due to loss to follow up High time and cost requirements Requires large sample size Difficult to eliminate confounding between correlated exposures (e.g. nutrient intakes)
Cross-sectional study	Health survey	Measurement of exposures, risk factors and disease prevalence at one point in time Studies relationships (associations) between exposures and outcomes	Low probability of selection bias, recall bias Study multiple exposures and outcomes Can control for possible multiple confounders	Requires large sample sizes Temporality of associations is not known Cannot measure incidence
Case–control study	Case–reference	Comparison of group of identified cases with a group of healthy controls. Exposure is measured retrospectively Compares level of past exposure (e.g. diet) in cases and controls	Smaller sample size than cohort study Low time and cost requirements Prospective case–control studies are possible	High probability of selection bias, recall bias, confounding. Potentially low reliability of findings Temporality of associations often not known Can only test one outcome
Ecological study	Correlational	Investigates the relationship between exposure and disease in grouped data (e.g. regions, countries)	Low time and cost requirements High potential for investigating causes of rare diseases	Inaccuracy of data Ecological fallacy: confounding cannot be controlled

Source: adapted from Bonita *et al*. (2006) and Thiese (2014).

interest was to understand whether increasing body mass index (BMI) is a risk factor for the onset of type 2 diabetes, age needs to be taken into account, either by analysing the effect of BMI in age groups or by statistical adjustment for age. This is important for the two reasons stated at the beginning of this paragraph. First, age and BMI are associated, such that BMI tends to increase with age, and second age and onset of type 2 diabetes are associated, such that its incidence increases with age. The design of studies and procedures in statistical analysis can take into account the problem of confounding, which in this example involves disentangling the effects of age and BMI. Confounding is an important problem in nutritional epidemiology because diet is a complicated and multifactorial exposure or, more accurately, set of exposures. In recognition, there has been a shift away from studies of the health effects of individual foods and nutrients towards identifying dietary patterns (such as the Mediterranean diet), and examining how a healthy diet may promote health.

Trials have the potential to generate stronger evidence with minimal or no confounding, since confounding is controlled for in the study design. A trial, randomised controlled trial or intervention study differs from an observational study in that the researcher seeks to compare two or more groups that differ as a result of

deliberate action rather than natural or observed variation. The researcher uses randomisation to allocate individuals to the intervention and control groups in the reasonable expectation that all confounder levels will be the same in the two groups. Then, if the condition of the two groups differs at the end of the trial, it can only be the result of the intervention. Unfortunately, randomised controlled trials using foods or whole diet as intervention are rare because they are impractical, particularly if the health outcome is chronic disease such as heart disease or cancer, when the trial would need to continue for perhaps 20 years. From an ethical standpoint, it is not possible to feed people with suspected disease-causing nutrients. With the exception of health-promoting nutrients such as vitamins, therefore, we can only test diet–disease hypotheses in observational and prospective cohort studies.

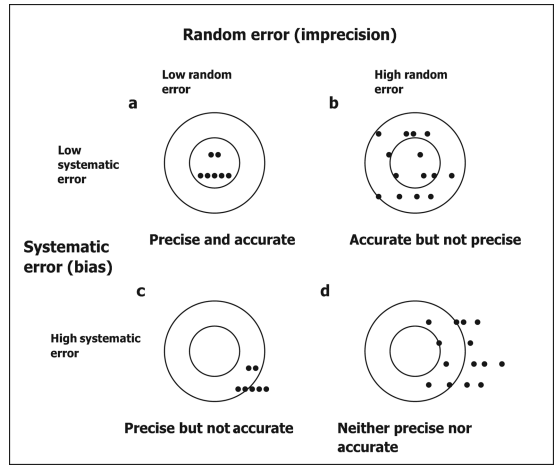

Figure 2.1 Representation of the effects of random and systematic error on measurements: (a) measurements that are both accurate and precise; (b) accurate measurements free of systematic error but affected by random error; (c) measures free of random error but affected by systematic error (inaccurate but precise); (d) measures that include both systematic and random error (inaccurate and imprecise). *Source*: Adapted from Gerstman (2003).

2.4 Measurement error and bias

Measurement error is an important issue in large-scale nutrition research, which often depends on self-reported dietary data. Whether a study seeks to describe the occurrence of a nutritional problem or to analyse the dietary causes of disease, there are always problems of measurement. Measurement error can be defined as the difference between the measured exposure, such as the usual dietary intake of fat, and the true exposure.

Error may be either systematic or random. Random error occurs with all measurements and is generally regarded as being caused by chance (Figure 2.1). Random error causes imprecision, or noise, in the estimate of food intake in a group of people, and can be reduced by increasing the number of observations or by improving quality control procedures when making measurements. Systematic error (or bias) is error that occurs in a consistent direction and reduces the accuracy of a measurement. Systematic error, unlike random error, is not smaller in larger studies. The consequences of measurement error are a loss of accuracy and precision, terms which have a specific meaning in scientific method. Accuracy is the degree of closeness of the measurement to its true value (see Figure 2.1a and b). Precision refers to the ability to measure without random error and means that measurements have high repeatability. Intuitively, we can predict that accurate and precise measurements of dietary intake will produce more valid results, and vice versa.

Measurement errors may arise for many reasons. There may be a flaw in the design of the measurement instrument or it may be poorly calibrated. Errors will be introduced by researchers who do not follow standard operating procedures during data collection and during processing of the raw data. Characteristics of the study participant, such as their degree of obesity and level of health consciousness, are sources of error when dietary assessment is based on self-report. Food tables, from which nutrient intakes are derived, are approximate. Techniques to estimate or reduce the effects of measurement error are available, but often not employed. Validation techniques have been used to estimate dietary measurement error by using biological measures such as 24-h urinary excretion of nitrogen (to estimate protein intake), potassium or sucrose, or circulating concentrations of vitamins C and E, carotenoids or retinol, or fatty acids, but biomarkers are only available for a limited set of nutrients.

In contrast to validation, which attempts to identify the type and scale of measurement error, calibration techniques adjust for systematic over– or underestimation of dietary intakes between studies and populations. An example is the calibration of dietary intakes using a method considered more accurate than the main method when estimating the association between disease risk and dietary intake. The EPIC-Europe Study (European Prospective Investigations into Cancer and Nutrition Study) utilised a calibration method by incorporating data from a standardised computer-based 24-h recall to make an improved estimate of the association between diet, estimated using a food frequency questionnaire, and risk of colorectal cancer in 10 European countries (Norat *et al*., 2005). Another example is the biomarker-calibrated

association between carotenoid intake and incidence of cataracts, which utilised a biomarker in addition to the dietary estimate of carotenoids (Freedman *et al.*, 2011). Addition of the biomarker strengthened the association between carotenoids and incidence of cataract formation.

Dietary intake is generally measured by some form of diary or questionnaire. The weighed intake method, which requires the study participant to weigh and record every item of food eaten for several days, is considered to be one of the most accurate methods. This activity is a burden and it is not surprising that many studies adopt simpler and easier methods to measure dietary intake, such as a food frequency questionnaire asking respondents to estimate how often, on average, they eat a given food over a year. These methods are less burdensome than a food diary, but the trade-off is likely to be increased measurement error.

Measurement errors have important impacts on the interpretation of dietary studies. When the aim is to understand the true association between diet and a disease outcome, the accuracy and precision of the study measures must be carefully considered in order to evaluate the extent to which the observed association between dietary intake and disease outcome is valid (Schatzkin and Kipnis, 2004). The fundamental objective in nutritional epidemiology is often to classify the dietary intake of each participant in a study, so that the group can be ordered correctly (ranked) according to their level of intake. As the degree of measurement error increases, misclassification increases, and the observed association between dietary intake and disease will increasingly be distorted.

Specific forms of bias can occur when measuring dietary intake. Reporting bias, or social desirability bias, occurs when respondents report what they think is an acceptable level of intake; for example, reporting less alcohol or higher fruit and vegetable consumption than is actually the case. This common behaviour leads to misreporting (under– or overreporting) of nutrient and energy intake. It is known that underreporting of energy intake increases with increasing BMI (Bingham *et al.*, 1997; Brunner *et al.*, 2001). As a result, contradictory findings may emerge, such that obese people appear to have lower energy intake than thinner or normal weight people. Misreporting is common. It is linked not only with higher BMI, but other variables such as socioeconomic status. Researchers have tried to reduce this source of bias by excluding the data from individuals who under– or overreported the most, but such an approach is no longer recommended because it introduces further bias, known as selection bias, which distorts estimates of the quantities or relationships of interest (Stubbs *et al.*, 2002).

Recall bias is another type of reporting bias, known for producing spurious findings in case–control studies of chronic diseases such as cancer. Recall bias leads to systematic differences in recall due to current or prior events or experiences. Although it may be convenient to measure past diet at the time of onset of a disease in a study of disease causation, there is a risk that recall of behaviours including diet (perhaps two decades earlier) will be influenced by knowing the diagnosis, while recall bias in the control or comparison group might be quite different. The net result is that the risk factors identified in such retrospective studies may reflect current popular attitudes to diet and health as much if not more than the actual past differences in diet between cases and controls. A further problem with recall of past diet is that current diet has been found to influence recall of past diet to a large extent (Willett, 2013).

Publication bias undermines the validity of many fields of science, and is the consequence of selective publication of positive results. In some cases, the body of evidence on a topic, particularly when financial interests are involved, may need to be examined carefully to check that it is valid. How best to support weight loss in overweight and obese people is an issue of great significance at present. A recent trial found that significant weight loss was eight times more likely after 6 months with behavioural counselling in a supportive group than with self-motivation alone (Johnston *et al.*, 2013) Such an effect may be valid and generally applicable; however, Weight Watchers International paid for the study and presumably did so because it wished to generate evidence for commercial advantage. In such situations, it is reasonable to consider whether results may need to be replicated by an independent research group, without commercial involvement.

Research in the field of nutrition is influenced by various parts of the food and dieting industry. Beyond potential publication bias, it is appropriate to ask whether certain research topics are neglected because the industry is rich, whereas public research funds are scarce. As a result, research on benefits and harms and the effectiveness of different interventions to achieve behaviour change is lacking (Kivimaki *et al.*, 2015). Those working in health care and public health who are required to develop health interventions or policy should be aware of the types of potential bias that may have occurred in shaping the body of evidence when making their decisions.

2.5 Interpretation of study design and hierarchy of the evidence

Many factors may influence the validity of a study. If the body of evidence supporting a policy action in public

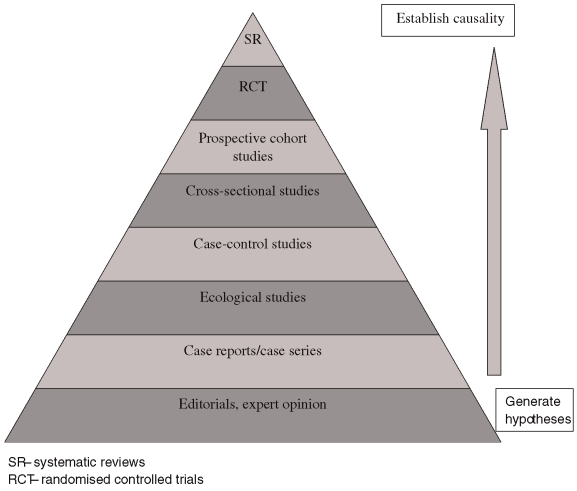

Figure 2.2 Hierarchy of epidemiological study design for establishing causality. SR: systematic review; RCT: randomised controlled trial.

health nutrition is based mainly on weak study designs, then the policy decision is open to challenge. The 'hierarchy of evidence' shown in Figure 2.2 is a general guide to the strength and quality of findings according to the design of the study. Designs located higher up the pyramid will tend to provide more solid evidence than those nearer the base. Public health practitioners need to be aware of this hierarchy and the advantages and disadvantages of the different study designs detailed in Table 2.1. Systematic reviews, which are literature reviews that collect and critically analyse multiple research studies or papers according to a predetermined protocol, are considered the optimal type of evidence for making decisions in public health nutrition. Randomised controlled trials are considered to be the type of study design that is best to infer causation. However, designing randomised controlled trials in nutrition can be difficult. A randomised trial is practical for testing the effectiveness of a drug in acute disease; for example, an antibiotic in patients with blood poisoning. Demonstrating that one dietary pattern is superior to another in preventing heart attacks is a more challenging task altogether.

When interpreting the results of studies associating diet with health or disease outcomes it is important to understand the size or scale of the effects that are found and to interpret them in relation to a number of factors, including study design (McLeod *et al.*, 2016). It is often the case that the size of a relationship will be small. If the study is large, the associations will be statistically significant, and vice versa. In this context, it is important to consider whether the scale or size of the effect of the relationship found has clinical and/or public health relevance (McLeod *et al.*, 2016).

2.6 Risk assessment versus risk management

Risk assessment in public health characterises the nature and size of the health risks associated with particular exposures. Risk assessment by means of surveys and clinical screening provides the motivation for public health nutritionists to act. The next step is risk management, involving intervention rather than observation. Risk management refers to the planning and implementation of actions to reduce or eliminate risk. What we need to know here is how best to achieve the change in dietary intake that is wanted. If we can put together strong evidence on the links between diet and health, along with strong evidence on the effectiveness and cost-effectiveness of interventions to change the target population's diet, then we have a formula for positive change. See Figure 2.3.

Risk assessment is a fundamental activity in public health that helps to identify priorities for action, or risk management. Examples of sources of population surveillance information available for the UK are shown in Box 2.3 These surveys provide data for trends in food consumption, obesity and other health-related factors. Such information is usually broken down into demographic groups including sex, age group, region and socioeconomic position. At present, there is widespread concern about the high prevalence of obesity in the UK and other countries. In just 30 years, adult obesity prevalence has risen threefold in England, from about 8% in the early 1980s to 25% in 2011. The challenge of epidemic obesity is that effective solutions are hard to find either for prevention or treatment.

Figure 2.3 Risk analysis framework.