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Victor R. Preedy
Vinood B. Patel
Editors

Handbook of Famine, Starvation, and Nutrient Deprivation

From Biology to Policy

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With 479 Figures and 226 Tables

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Preface

There are numerous definitions of the terms malnutrition, undernutrition, and starvation, many of which are used interchangeably. Strictly speaking, malnutrition also refers to an "imbalance" and includes an excess of nutrients. However, within the context of this handbook we are primarily concerned with a lack or deficiency of one or more dietary components rather than an excess. Embedded within the deficiency states is "acute restriction" whereby food is withdrawn or deliberately not consumed at all. For example, individuals may refrain from eating to provide blood samples for subsequent analysis or food may be withdrawn from patients before surgery. Further downstream is the consumption of a fraction of the diet, or none at all. This may arise when there are restrictions in the amount of food available to an individual or population. The causes of such restrictions in dietary intake are varied and include poverty, conflict, and regional famine. In the sociogeographical context, refugees and displaced persons may also be vulnerable to undernutrition.

Some diseases will impact on the total food consumed, for example, when there are physical impediments (intestinal obstruction or dysphagia) or anorexia. There may also be restrictions in the availability of single micro- or macronutrients such as vitamins, minerals, proteins, lipids, or dietary energy. There may be increased bodily demands for certain nutrients in some diseases, but these may not be met by the existing diet, thus resulting in deficiency states.

The impact of such dietary restrictions is variable. Deficiencies in micro- or macronutrients will impact on cells, organs, individuals, and even populations. Quality of life measures, for example, are impaired in anorexia and in famine. Some communities are blighted by the absence of specific micronutrients which impact on physical and mental health: endemic iodine deficiency is a good example of this.

It is important to understand the causes of nutrient deficiencies and also to be aware of the impact on the cell-to-community continuum. The knowledge gained from understanding how cells and organs respond to nutrient deficiencies may be transferable to understanding and treating deficiency diseases. At the population level, it is important to know how to diagnose and treat nutritional deficiencies. In the wider context, food waste and food insecurity are at opposite ends of the spectrum but have in common the disparities between provision and need. Policies

and procedures to address the aforementioned are required to reduce food waste and food insecurity.

There is a wide range of information that interlinks the complexities of undernutrition, disease, famine, sociology, food waste, food insecurity, poverty, provision, need, policies, and procedures. Hitherto, this has been sporadically distributed across different publications. This is resolved in the *Handbook of Famine, Starvation, and Nutrient Deprivation: From Biology to Policy.* It has wide coverage and also includes social aspects, refugees, conflict, hunger, anorexia, screening tools, medical causes of malnutrition, endocrinology, metabolism, tissue systems, life stages, micronutrients, modeling, cellular and molecular biology, international aspects, and management.

There are 12 parts as follows:

1. General Aspects of Famine and Undernutrition: Setting the Scene
2. Effects of Famine
3. Food Insecurity, Security, and Waste
4. Biosocial and Social Aspects, Inequalities, Low Income, Refugees, and Conflict
5. Hunger and Anorexia
6. Screening Tools, Classifications, and Applications
7. Medical Causes of Malnutrition, Prevalence, and Impact
8. Effects of Undernutrition, Endocrinology, Metabolism, and Tissue Systems
9. Life Stages, Pregnancy, the Young and Elderly
10. Micronutrients
11. Modeling Systems, Cellular and Molecular Effects
12. International Aspects, Policy, Management, Case Study, and Resources

The editors recognize the fact that it has been difficult to allocate specific chapters to the different parts. Some chapters may be suitably placed in different parts of the book. Nevertheless, the information in the *Handbook of Famine, Starvation, and Nutrient Deprivation: From Biology to Policy* is wide ranging. To bridge the intellectual divide and to provide guidance, each chapter has three sections as follows:

Policies and Protocols
Dictionary of Terms
Summary Points

Contributors are authors of international and national standing, leaders in the field, and trendsetters. Emerging fields of nutritional science and important discoveries are also incorporated in this book.

This book is designed for nutritionists and dietitians, public health scientists, doctors, epidemiologists, biologists, health-care professionals of various disciplines, policy makers, governmental bodies, and strategists. The *Handbook of Famine,*

Starvation, and Nutrient Deprivation: From Biology to Policy is designed for teachers and lecturers, undergraduates and graduates, researchers, and professors and as a library resource.

Victor R. Preedy
Vinood B. Patel
The Editors

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About the Editors

Victor R. Preedy (**B.Sc., Ph.D., D.Sc., FRSB, FRSPH, FRCPath, FRSC**), is a staff member of the Faculty of Life Sciences and Medicine at King's College London. He is also a member of the Division of Diabetes and Nutritional Sciences (research) and the Department of Nutrition and Dietetics (teaching). Professor Preedy is also Director of the Genomics Centre of King's College London.

Professor Preedy graduated in 1974 with an honors degree in biology and physiology with pharmacology. He gained his University of London Ph.D. in 1981. In 1992, he received his membership of the Royal College of Pathologists, and in 1993, he gained his second doctorate (D.Sc.) for his outstanding contribution to protein metabolism in health and disease. Professor Preedy was elected as Fellow to the Institute of Biology in 1995 and to the Royal College of Pathologists in 2000. In 2004, he was elected as Fellow to the Royal Society for the Promotion of Health and to the Royal Institute of Public Health. In 2009, he became Fellow of the Royal Society for Public Health and, in 2012, Fellow of the Royal Society of Chemistry. Professor Preedy has carried out research at the National Heart Hospital (part of Imperial College London), the School of Pharmacy (now part of University College London), and the MRC Centre at Northwick Park Hospital. He has collaborated with research groups in Finland, Japan, Australia, the USA, and Germany. He is a leading expert in the science of health and has a long-standing interest in nutrition and disease. He has lectured nationally and internationally. To his credit, Professor Preedy has published over 600 articles, which include peer-reviewed manuscripts based on original research, abstracts and symposium presentations, reviews, and numerous books and volumes.

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Dr. Vinood B. Patel (**B.Sc., Ph.D., FRSC**) is a Reader in Clinical Biochemistry at the University of Westminster and Honorary Fellow at King's College London. Dr. Patel graduated from the University of Portsmouth with a degree in pharmacology and completed his Ph.D. in protein metabolism from King's College London in 1997. His postdoctoral work was carried out at Wake Forest University Baptist Medical School studying structural-functional alterations to mitochondrial ribosomes, where he developed novel techniques to characterize their biophysical

properties. Dr. Patel is a nationally and internationally recognized scientist, and in 2014 he was elected as Fellow to the Royal Society of Chemistry. He presently directs studies on metabolic pathways involved in diabetes and liver disease, particularly related to mitochondrial energy regulation and cell death. He is currently conducting research to study the role of nutrients, antioxidants, phytochemicals, iron, alcohol, and fatty acids. His other areas of interest include identifying new biomarkers that can be used for the diagnosis and prognosis of liver disease and understanding mitochondrial oxidative stress in Alzheimer's disease and gastrointestinal dysfunction in autism. Dr. Patel has edited biomedical books in the areas of health preventive nutrition and biomarkers and has published over 150 articles.

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Part I

General Aspects of Famine and Undernutrition: Setting the Scene

Biafran Famine

1

Mikael Norman and Peter Ueda

Contents

Abstract

Following ethnic, economic, and religious tensions, the republic of Biafra unilaterally declared independence from the rest of Nigeria in 1967. This action triggered the Nigerian civil war in which the inflow of food and supplies to Biafra was blocked.

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The result was extensive famine, regarded as one of the great nutritional disasters of modern times. During the two-and-a-half years of armed conflict, an estimated one to three million people died, most of them from starvation.

Forty years later, adults in Enugu (the former capital of Biafra) who had been conceived or born during the famine and who survived the famine show health problems with two-to-three times higher prevalence of hypertension, glucose intolerance, and overweight than those born before or after the war. These findings support that undernutrition early in life have significant and adverse impact on human development and physiological design, eventually contributing to an increased risk for noncommunicable diseases in adulthood such as ischemic heart disease, stroke, and diabetes. The long-term effects of undernutrition during pregnancy and in infancy should be considered and receive high priority when setting goals for global health, education, and economic agendas.

Keywords

Sub-Saharan Africa · Nigeria · Biafran famine · Developmental origins of health and disease · Fetal undernutrition · Intrauterine growth restriction · Low birth weight · Metabolic syndrome · Diabetes · Hypertension · Overweight · Obesity

List of Abbreviations

BMI	Body mass index
OR	Odds ratio
SBP	Systolic blood pressure

Introduction

Epidemiological evidence supported by experimental data suggests that public health problems emerging in adult life are not only determined by genes and adult life-style, but also by perinatal factors acting before and shortly after birth (Barker 1998; Gluckman and Hanson 2004; Armitage et al. 2004; Gluckman et al. 2009). According to this concept, early living conditions – of which fetal nutrition is a key component – shape not only our ability to survive birth and infancy, but also our physiological capacity to respond to health challenges occurring later in life. In this way, developmental plasticity in response to early under- or malnutrition can be considered an important, underlying mechanism explaining why adults born small – a proxy for fetal starvation – are at increased risks for cardiovascular disease and diabetes.

In the twenty-first century, the prevalence of obesity, hypertension, and insulin resistance, i.e., the metabolic syndrome (sometimes also including a proinflammatory and prothrombotic state) has increased (Manson et al. 2004; Franks et al. 2010). The metabolic syndrome is the most important predictor of cardiovascular disease and type 2 diabetes (Rapsomaniki et al. 2014; Ekblom-Bak et al. 2009). In developed countries

around 15% of the adult population is affected and in the developing world, rates of metabolic syndrome are rapidly becoming even higher. As a result, 80% of all new cases of diabetes and 85% of all deaths in cardiovascular disease are estimated to occur in low-middle income countries by 2025–2030 (Joshi et al. 2008).

Although infections still plague many Sub-Saharan African countries, non-communicable diseases are emerging as leading causes of morbidity and death (Unwin 2001). Besides better economy and successful vaccination and educational programs, this change in epidemiology is commonly attributed to rural-to-urban shifts in adult lifestyle, typically involving obesity-promoting diet, lack of exercise, and cigarette smoking (Yach et al. 2004). However, there may also be a significant perinatal contribution to this development. In particular, people who suffered from undernutrition in utero and who later in life become exposed to nutritional affluence are thought to run the greatest risks of cardiovascular disease and diabetes (Barker et al. 1993; Barker 1998; Gluckman and Hanson 2004).

The role of undernutrition during pregnancy for future childhood and adult health has been evaluated in different settings exposed to famine, most of them outside Sub-Saharan Africa (1991; Ravelli et al. 1998, 1999; Roseboom et al. 1999, 2001; Victora et al. 2003, 2008; Bhargava et al. 2004; Richter et al. 2004; Sachdev et al. 2005; Grajeda et al. 2005). Given limited resources, previous and ongoing maternal – infant undernutrition (Black et al. 2008) and growing numbers affected by cardiovascular disease, obesity, diabetes, and hypertension (Ike 2009; Unwin 2001), the significance of poor fetal-maternal health for adult disease risk, would be of great importance to clarify in Sub-Saharan Africa as well. To do so, researchers from Sweden and Nigeria focused on long-term health among adult survivors of the Biafran famine occurring almost 50 years ago in Nigeria (Hult et al. 2010).

The Biafran Famine

In 1960, Nigeria became independent from United Kingdom. As with other new African states, the borders of the country did not reflect earlier ethnic boundaries, resulting in social unrest. As a culmination of ethnic and religious tensions, civil war broke out in Nigeria on 6 July 1967, after the Igbo people in the south-eastern part had declared independence as the Republic of Biafra. The struggle for control over the large amount of oil in the southeastern Nigeria is also likely to have contributed to armed conflict.

Disapproving of the secession, federal Nigerian forces rapidly encircled Biafran territory and inflow of food to this densely populated enclave was stopped. The resulting famine was extensive and has been regarded as one of the greatest nutritional disasters of modern time (Miller 1970). Of the estimated one to three million Biafrans that lost their lives, only a small fraction (10%) died in military actions and the rest from starvation. International relief actions were launched but they were insufficient and the majority of Igbos did not get access to food from these aid programs (Aall 1970). The war ended in January 1970, Fig. 1.