

Nutrition and Health

Series Editors: Adrienne Bendich · Connie W. Bales

Carol J. Lammi-Keefe · Sarah C. Couch
John P. Kirwan *Editors*

Handbook of Nutrition and Pregnancy

Second Edition

 Humana Press

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The Nutrition and Health series has an overriding mission in providing health professionals with texts that are considered essential since each is edited by the leading researchers in their respective fields. Each volume includes: 1) a synthesis of the state of the science, 2) timely, in-depth reviews, 3) extensive, up-to-date fully annotated reference lists, 4) a detailed index, 5) relevant tables and figures, 6) identification of paradigm shifts and consequences, 7) virtually no overlap of information between chapters, but targeted, inter-chapter referrals, 8) suggestions of areas for future research and 9) balanced, data driven answers to patient/health professionals questions which are based upon the totality of evidence rather than the findings of a single study.

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Editors

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To Patrick, and our sons, Liam and Christopher, for the love, support, and encouragement provided and for embracing our family mantra, “We do the best we can.”
— Carol J. Lammi-Keefe

To my wife April; kids—Jennifer, Brent, Lani, and Aran; and grandkids—Hannah, Charlotte, and Addie. You are the constants, the purpose, and the inspiration of my life.
— John P. Kirwan

To my mother Sally Collins, whose caring nature, love of science and medicine, and zest for life are a daily inspiration to me.
— Sarah C. Couch

Foreword

This is not a typical handbook of nutrition and pregnancy that reviews the effect of pregnancy on nutrient requirements and how to meet those needs. Instead, it reviews the diverse nutritional *challenges* providers need to address when counseling pregnant women in developed and developing countries. The editors recognize that there is no “one-size-fits-all” approach for counseling all pregnant women about nutrition. Thus, they created a handbook that gives doctors, nurses, dietitians, and other health care professionals the information and tools they need to manage the wide range of pregnancy-related nutrition issues existing worldwide.

Unfortunately, today many women still enter pregnancy with underlying nutrition concerns that influence their metabolic adjustments to pregnancy and fetal nutrition. Fifty years ago, an insufficient nutrient intake was the primary concern. Pregnancy was thought to be a risk factor for iron-deficiency anemia, and iron supplementation was a common practice. Iron-deficiency anemia still exists, but the emphasis has shifted to the provision of *optimal* amounts without increasing adverse pregnancy outcomes due to elevated hemoglobin levels. Also, today nutritional concerns have expanded beyond iron. The unique iodine, vitamin D, and the one-carbon nutrient (folate, vitamin B12, vitamin B6, and choline) needs for maternal and fetal health are addressed in this edition. Plus, there is a new chapter on “epigenetics and diet in pregnancy” that describes the link between maternal nutrition and the long-term health of the child.

Maternal obesity is another theme throughout the handbook. Obesity, its metabolic consequences (gestational diabetes and preeclampsia), and the associated eating disorders or surgical treatment procedures all influence fetal health and subsequent growth and development of the child. Furthermore, the problem of obesity is exacerbated by the pregnancy metabolic changes that enhance maternal fat gain. In an ideal world, all women of reproductive age would receive counseling for achieving a healthy body weight prior to conception. But, given the prevalence of this problem worldwide, this is highly unlikely. For example, the World Health Association predicts that in 2030 nearly one-fifth of the women in lower income countries, such as sub-Saharan Africa, will be obese. A more feasible goal may be to use the pregnancy period as a teaching moment to improve the diet quality and

weight management of the whole family unit during and following pregnancy. The principles of nutrition described throughout this book could provide the basis for achieving that goal.

A third general theme of the handbook is the effects on pregnancy outcomes of a stressful lifestyle that many women of reproductive age are experiencing today. Depression, sleep disorders, domestic violence, and incarceration all fall into that category. Often health providers do not address these topics, even though they likely have a huge impact on diet quality and nutrient metabolism. The authors of these chapters not only review the effect of these conditions on maternal nutrition and health but, most importantly, they also suggest interventions or programs for improving the health of these women.

In summary, the 22 outstanding chapters in this book provide the latest evidence for managing the nutritional requirements of pregnant women in diverse settings worldwide. The authors recognized that one size does not fit all, and they clearly explain how to modify the dietary counseling for an individual woman's unique needs. The *Handbook of Nutrition and Pregnancy*, 2nd edition, is an excellent, easy-to-use resource for all health care providers.

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Preface

Handbook of Nutrition and Pregnancy, second edition, is written for clinicians and healthcare professionals who treat and counsel pregnant women and women of childbearing age. Reflecting new knowledge since the first edition was published in 2008, this second edition has updated recommendations, and it also includes coverage of topics that were not in the first edition, including body composition changes in pregnancy, US Hispanics and preterm births, epigenetics and diet in pregnancy, and safe food handling for successful pregnancy outcomes, as examples. This handbook is a resource for physicians, physician assistants, nurse practitioners, and dietitians, while students of nutrition and dietetics and medical and graduate students will also find this book a useful resource. Chapters provide historical perspectives and background supporting the recommendations made in each of the chapters. *Handbook of Nutrition and Pregnancy*, second edition, is a resource for practitioners and researchers all over the globe.

We live in an era of major scientific advances in which mining large data sets that include genes, metabolites, and proteins is yielding new insights into biological function as they relate to nutrition. Over the last decade, scientists have made giant steps toward individualizing nutrition in response to our growing knowledge of the human genome. It is now well recognized that prenatal and perinatal nutrition, along with environmental factors, is inextricably linked to childhood and adult obesity and chronic disease. In this new edition, we include the topic of diabetes in pregnancy and review the challenges of estimating the global prevalence of gestational diabetes, with its trends in at-risk groups. The overall objective for this new edition of the *Handbook of Nutrition and Pregnancy* is to provide current information and recommendations and to translate that information into clinically relevant practice recommendations.

This volume is arranged to address five major categories related to nutrition for successful pregnancy outcomes and also includes topics that have not heretofore been broadly written about or discussed, namely, incarcerated pregnant women, sleep during pregnancy, depression *in* pregnancy, and domestic violence during pregnancy.

Handbook of Nutrition and Pregnancy, second edition, is comprehensive with up-to-date information in twenty-two chapters written by leaders in the fields of nutrition and food science, environment, physiology, metabolism, and genetics and epigenetics while addressing the needs of women of childbearing ages and pregnant women. This volume contains information that brings the reader up to date on the state of the science and permits the reader to respond to practical queries from patients, family members, students, and researchers. It is the editors' vision that work contained in this edition will meet the needs of practitioners, researchers, and students who work with pregnant women and open the door to areas of new scientific investigation that will enhance the health and quality of life of mothers and their babies.

Series Editor Page

The great success of the Nutrition and Health Series is the result of the consistent overriding mission of providing health professionals with texts that are essential because each includes (1) a synthesis of the state of the science, (2) timely, in-depth reviews by the leading researchers and clinicians in their respective fields, (3) extensive, up-to-date fully annotated reference lists, (4) a detailed index, (5) relevant tables and figures, (6) identification of paradigm shifts and the consequences, (7) virtually no overlap of information between chapters, but targeted, interchapter referrals, (8) suggestions of areas for future research, and (9) balanced, data-driven answers to patient as well as health professionals' questions which are based upon the totality of evidence rather than the findings of any single study.

The series volumes are not the outcome of a symposium. Rather, each editor has the potential to examine a chosen area with a broad perspective, both in subject matter and in the choice of chapter authors. The international perspective, especially with regard to public health initiatives, is emphasized where appropriate. The editor(s), whose trainings are both research and practice oriented, have the opportunity to develop a primary objective for their book, define the scope and focus, and then invite the leading authorities from around the world to be part of their initiative. The authors are encouraged to provide an overview of the field, discuss their own research, and relate the research findings to potential human health consequences. Because each book is developed *de novo*, the chapters are coordinated so that the resulting volume imparts greater knowledge than the sum of the information contained in the individual chapters.

“Handbook of Nutrition and Pregnancy, Second Edition,” edited by Carol J. Lammi-Keefe, Sarah C. Couch, and John P. Kirwan, is a very welcome and timely addition to the Nutrition and Health Series and fully exemplifies the series' goals. This volume represents a critical, in-depth review of the current life events that can adversely impact pregnancy outcomes for women across the globe. The increased risks associated with obesity during pregnancy as well as weight loss surgery are examined in detail. Ethnic dietary patterns of Hispanic women are detailed to better understand their potential effects on increasing preterm births. The medical conditions of anorexia, bulimia, and binge eating and their effects on pregnancy outcomes

are examined. Unique chapters look into the role of sleep patterns, depression, domestic violence, and pregnancy during incarceration on pregnancy outcomes. Of importance the volume also contains reference-rich chapters on the newest research concerning single as well as related nutrients including vitamin D, iodine, and iron and the B vitamins involved in one-carbon metabolism. New fields of research including epigenetics are also highlighted. Thus, the volume is designed as an important resource for physicians in many clinical fields, nutritionists and dietitians, research and public health scientists, and related health professionals who interact with women of childbearing potential as well as women who are planning pregnancy, are pregnant, and women who have given birth and are lactating. The volume provides objective and relevant information for professors and lecturers, advanced undergraduates and graduates, researchers, and clinical investigators who require extensive, up-to-date literature reviews, instructive tables and figures, and excellent references on all aspects of pregnancy, diet, and health as well as nutrition's role in enhancing the potential for optimal pregnancy outcomes. This volume is especially relevant as the number of research papers and meta-analyses in the clinical nutrition arena increases every year and clients and patients are very interested in dietary components such as vitamins and minerals, fatty acids, and protein needs during pregnancy. Certainly, the obesity epidemic remains a major concern especially as the comorbidities, such as the metabolic syndrome, gestational maternal diabetes, and type 2 diabetes prior to pregnancy, hypertension, and hyperlipidemia, are seen more frequently now than ever before in women during pregnancy. The adverse effects to both mother and child are reviewed in depth in related comprehensive chapters.

The editors of this comprehensive volume are experts in their respective fields of clinical research and practice. Carol J. Lammi-Keefe, Ph.D., is Alma Beth Clark Professor of Nutrition, School of Nutrition and Food Sciences, Louisiana State University, and Adjunct Professor at the Pennington Biomedical Research Center, Baton Rouge, Louisiana. Dr. Lammi-Keefe served as the primary editor of the first edition of the *Handbook of Nutrition and Pregnancy* that was published in 2008. For more than three decades, she has published critical studies in the areas of maternal and fetal nutrition, with an emphasis on lipids and especially omega-3 fatty acids. Her research findings include the benefit of docosahexaenoic acid (DHA) during pregnancy on infant functional outcomes, including sleep, visual acuity, problem solving, and decreased adiposity. Her research findings have been published in journals including the *American Journal of Clinical Nutrition*, the *Journal of the American Dietetic Association*, *Lipids*, the *British Journal of Nutrition*, and the *Journal of Pediatric Gastroenterology and Nutrition*. As principal investigator or co-investigator, her research support has come from the U.S. Department of Agriculture, the National Institutes of Health, and numerous foundations, boards, institutes, or industry. A current federally funded project will assess the benefit of omega-3 fatty acids in decreasing the inflammatory response in overweight pregnant women and the effect on infant adiposity.

Dr. Lammi-Keefe's professional activities include serving as Past Chair of the Health and Nutrition Division for the American Oil Chemists Society and

membership in the American Dietetic Association, American Society for Nutrition, International Society for the Study of Fatty Acids and Lipids, and International Society for Research on Human Milk and Lactation. She is a former member of the Governing Board for the American Oil Chemists Society. Prior to joining the faculty of Louisiana State University, she was a faculty member and Department Head at the University of Connecticut from 1981 to 2006 and she retains her Professor Emeritus status. In 2003 she was recognized by the university with the Chancellor's Research Excellence Award. For her research and scientific contributions, the American Dietetic Association Foundation presented her with its Ross Award in Women's Health and its Award for Excellence in Dietetic Research. In 2009, Louisiana State University cited her as a "Rainmaker."

Sarah Couch, Ph.D., R.D., is a professor and Director of the Graduate Program in Human Nutrition in the Department of Rehabilitation, Exercise and Nutrition Sciences at the University of Cincinnati. She has an M.S. and Ph.D. in nutritional sciences and is a registered dietitian specializing in evaluating dietary approaches in the prevention and management of cardiovascular disease risk factors. Dr. Couch has conducted human subject research for over 20 years, specifically examining dietary assessment approaches and dietary patterns related to cardiovascular disease risk reduction, and has authored over 65 peer-reviewed publications. She is a recipient of a grant award from the National Heart, Lung and Blood Institute to examine the efficacy of a DASH dietary pattern delivered as part of a clinic-based behavioral nutrition program for the management of elevated blood pressure in adolescents. Her studies have also involved assessment of the home food environment as a potential modifiable risk factor related to childhood obesity and CVD risk. Her particular interests related to the home environment are parenting style and child feeding practices and parent and adolescent food literacy in relation to diet quality and weight status.

John P. Kirwan, Ph.D., MSc, is Director of the Metabolic Translational Research Center and Professor of Molecular Medicine at the Cleveland Clinic in Cleveland, Ohio, USA. He is also a Professor of Nutrition, and of Physiology, at Case Western Reserve University School of Medicine in Cleveland. His professional expertise includes almost 30 years of research, teaching, and service in the obesity, diabetes, and nutrition fields. Dr. Kirwan received his clinical physiology training at Washington University School of Medicine in St. Louis, Missouri; his Ph.D. in human bioenergetics at Ball State University, Muncie, Indiana; and his MSc in exercise biochemistry from the University of Massachusetts, Amherst, Massachusetts; and his BA (Hons) from the University of Limerick, Ireland. Dr. Kirwan leads an internationally acclaimed biomedical research program focused on diabetes, obesity, nutrition, and exercise. To date, his research funding has been awarded from the US National Institutes of Health, and the food, pharmaceutical, and medical device industries. He has published over 200 scientific papers related to metabolism and nutrition in prestigious peer-reviewed journals including the *New England Journal of Medicine*, *JAMA*, *Diabetes*, and the *American Journal of Clinical Nutrition*. Among his most important research contributions is the discovery that, for a significant number of patients, diabetes can be cured by surgically altering the physiology of the intestine and stomach.

This volume, developed by three eminent editors, is organized into five parts: nutrient and health needs in pregnancy, metabolism during pregnancy, high-risk pregnancies, the postpartum period, and the developing world. The first part contains seven chapters and begins with the chapter that examines body composition in pregnancy. Chapter 1 reviews the physiologic and metabolic changes associated with pregnancy including all phases of gestational weight gain and examines the alterations in maternal body composition as well as embryonic and fetal growth. Numerous methodologies are described including anthropometry, whole body densitometry, underwater weighing, air displacement plethysmography, MRI, DXA stable isotope total body water measurement, and ultrasound. The importance of the measurement of gestational weight gain during the trimesters is discussed especially in view of the recent data linking increased weight gain with several adverse effects to both the mother and fetus.

The next three chapters review the importance of three essential nutrients for normal fetal growth as well as maternal health. Chapter 2 includes a risk/benefit analysis of the use of iron supplements during pregnancy. The chapter reviews the iron requirements of the fetus and emphasizes the significantly increased iron requirements of the fetus during the last trimester. Iron, as an essential micronutrient and as an element, must be consumed as it cannot be synthesized. However, it differs from most essential nutrients in that its excretion is very limited and thus absorption is under multiple controls that are affected further by pregnancy. The woman's optimal iron status prior to pregnancy helps to assure that both she and the newborn have adequate iron over the entire pregnancy. The chapter reviews the transport of iron including the hormones involved, genetic factors, and both heme and non-heme iron absorption during the pregnancy. Detailed discussions of iron deficiency and iron deficiency anemia as well as identification of risk groups are included. The practice of providing iron supplements to all pregnant women is examined in light of conflicting data from published studies and further research is suggested. Chapter 3 examines the developmental roles of iodine as this element is critical for the formation of thyroid hormones. Iodine requirements are increased during pregnancy as fetal growth is dependent upon sufficient synthesis of maternal thyroid hormones. Pregnant women have increased iodine requirements of 220–250 $\mu\text{g}/\text{day}$. Maternal iodine deficiency during pregnancy can have adverse obstetrical effects such as miscarriage, prematurity, and stillbirth, as well as adverse effects on offspring development including low birth weight and head circumference, and lower cognitive functions. Food sources of iodine are identified and the indirect determination of iodine status is reviewed. Iodine supplementation prior to pregnancy, during pregnancy and lactation is currently recommended in the USA. The adverse effects of both lower and higher recommended intakes of iodine during pregnancy are discussed. Chapter 4 reviews the recent findings on the importance of vitamin D during pregnancy and lactation and provides new data to support increases in daily supplementation levels during both pregnancy and lactation. These levels of supplementation remain controversial and thus this chapter is of particular value to health professionals who recommend vitamin D supplementation to the relevant women. We learn that the roles of vitamin D in the pregnant versus lactating woman

are different. In the pregnant woman, the primary role of vitamin D appears to be immunomodulatory while also retaining its calcium regulating function. During lactation, maternal vitamin D intake serves the primary role of supplying the nursing newborn infant with adequate vitamin D for its skeletal integrity function.

Chapter 5 examines the nutritional needs of women who consume vegetarian diets during pregnancy. The chapter provides information concerning the potential for a vegetarian or vegan diet to meet the nutritional requirements for all nutrients not provided by the vegetarian diet regardless of type (vegan, ovo-lacto, etc.) by adding fortified foods and/or supplements as needed. There are specially formulated vegetarian prenatal multivitamin-mineral supplements; however, these should be evaluated for adequacy for the individual woman during all trimesters as well as during lactation. Several of the at-risk nutrients for women who consume vegetarian diets include protein, iron, zinc, calcium, vitamin D, vitamin B12, iodine, and omega-3 fatty acids. The chapter includes tables that list the foods containing the at-risk nutrients and their contents in dietary supplements for pregnant vegetarians. As the prior chapters also include information on the increased requirements for iron, iodine, and vitamin D, these chapters should also be reviewed by health professionals who treat those consuming vegetarian diets.

Chapter 6 reviews the serious adverse effects of three major clinical sleep disorders and their consequences during pregnancy. The relationship of these disorders to dietary intakes is reviewed. The first condition discussed is insufficient sleep, also known as sleep restriction, and is known to negatively impact hormonal and metabolic function. We learn that short sleep duration is an independent risk factor for weight gain and obesity. Obstructive sleep apnea and restless legs syndrome are the two other common sleep disorders that are examined as both are influenced by diet and nutrition.

Chapter 7 reviews the importance of food safety for pregnant women. We are reminded that pregnancy is a time when a woman's immune system responses are reduced so that she does not reject her own fetus. Thus, pregnant women and their fetuses are at higher risk of food-borne illness than at other times during their adult lives. Moreover, during pregnancy, pathogenic microorganisms can cross the placenta, infecting the fetus because their immune system is not fully developed. These infestations can cause serious consequences including miscarriage, premature delivery, hearing loss, intellectual disabilities, blindness, and/or other serious sicknesses. Thus, safe food handling during pregnancy is critical for the health of the pregnancy. The safe food handling methods are reviewed in detail and the major pathogens and their sources are included in this informative and unique chapter.

Part II, containing two chapters, looks at the importance of one-carbon metabolism and certain consequences of deficiencies in the nutrients associated with normal one-carbon metabolism on the epigenetics of the fetus. Chapter 8 reminds us of the critical role of the essential vitamins (folic acid, vitamins B6 and B12) and the conditionally essential nutrient (choline) as methyl donors to genetic material and other key reactions in the development of the embryo and fetus and discusses the many adverse effects associated with deficiency in any one of these essential and conditionally essential nutrients. The chapter contains details pertaining to the

metabolic pathway that includes DNA methylation reactions, foods that contain these nutrients and their functions during pregnancy, and recommended intakes. Also, the frequency and effects of genetic factors that alter one-carbon metabolism are reviewed in depth, and consequences to the pregnancy are discussed separately from those effects on the fetus and neonate; the chapter includes over 150 relevant references. Epigenetics and diet in pregnancy is a relatively new area for investigation and Chap. 9 brings us up to date. Epigenetics is defined as modifications of offspring DNA that occur without changing their genetic sequences, but result in altered gene expression and function with subsequent changes in phenotype. The three main epigenetic mechanisms are DNA methylation, histone modification, and noncoding RNAs. As mentioned above, DNA methylation is the most widely studied evidence of epigenetic alterations in pregnancy. Maternal undernutrition, especially in the B vitamins discussed in Chap. 8, paternal undernutrition, and transgenerational effects of alterations in methylation of DNA and other epigenetic events are reviewed in detail and relevant consequences are outlined and tabulated.

Part III contains eight chapters that examine the most common as well as the most difficult pregnancies and the potential risks and benefits associated with dietary intakes during these pregnancies. Chapter 10 is of great importance as the number of women who enter pregnancy as either overweight or obese is increasing yearly around the globe. The chapter focuses on the most current and evidence-based clinical recommendations related to the U.S. Institute of Medicine's (IOM) gestational weight gain (GWG) guidelines from 2009 and the IOM updated 2015 practice paper, controversies related to these GWG guidelines, maternal and fetal outcomes associated with adherence and noncompliance to these GWG guidelines, a review of factors influencing GWG, and general and nutritional recommendations for the management of maternal obesity. The chapter reviews the serious adverse effects to both mother and infant during and following birth if a woman enters pregnancy obese and stresses the value of preconceptional weight loss. Chapter 11 reviews the risks and benefits of weight loss surgery, which is one option for reducing obesity prior to pregnancy. The chapter describes the different types of bariatric operations and the nutritional disturbances associated with each one. Additionally, the standard recommendations for supplementation and follow up are reviewed. Alterations to these regimens during pregnancy are discussed. Pregnancy outcomes after bariatric surgery are reviewed. The nutritional deficiencies in vitamins and other nutrients are common after bariatric surgery, and the differences between the types of surgeries are outlined and illustrated.

One of the most serious and devastating conditions affecting pregnancy is preeclampsia. Chapter 12 provides a comprehensive review and explains that preeclampsia is a multi-organ disease that occurs after 20 weeks gestation and is characterized by the development of hypertension and either proteinuria or other evidence of end-organ effects. Preeclampsia occurs in 5–7% of pregnancies. The exact etiology of the disorder continues to be poorly understood. Factors associated with preeclampsia include both poor placentation and placental hypoxia, resulting in a cascade of events that may culminate in increased maternal mortality and morbidity including placental abruption, acute renal failure, cerebrovascular and

cardiovascular complications, disseminated intravascular coagulation as well as fetal/neonatal morbidity and mortality caused by intrauterine growth restriction, abruption, and prematurity. There are no well-established methods of primary prevention or reliable and cost-effective screening. New research, described in the chapter, focuses on biomarkers that may be useful for screening in the future. With regard to nutritionally based interventions, calcium supplementation in high-risk women and in women with low dietary calcium intake has been shown to reduce the risk of hypertension and preeclampsia.

The next five chapters review population groups that are at higher than average risk of adverse pregnancy outcomes and provide options for risk reduction. Chapter [13](#) looks at the data linking Hispanic ethnicity in US women with increased risk of preterm birth. The chapter identifies critical factors associated with the increased risk including maternal socio-demographic characteristics, medical and pregnancy-related conditions, maternal lifestyle including dietary factors, and acculturation. Of note, vitamin D deficiency is a risk factor for preterm delivery and is more prevalent among Hispanic compared with non-Hispanic White women. The chapter discusses the increased prevalence of several known risk factors in Hispanic populations including Hispanic mothers who are 17 years old or younger and Hispanic women of childbearing age who have significantly higher rates of obesity, diabetes, and pregnancy-related diabetes and hypertension compared to non-Hispanic White women. Lower than recommended body weight before becoming pregnant also increased risk of preterm birth in Hispanic women. Chapter [14](#) looks at pregnancy risks in women who have serious eating disorders either before becoming pregnant or develop these conditions during pregnancy. The chapter reviews the adverse clinical effects of anorexia, bulimia, and binge eating and their nutritional consequences. These conditions are associated with inadequate or inconsistent energy and nutrient intakes, notably total energy; folate; vitamins B6, B12, and A; calcium; iron; and zinc. Electrolyte imbalances are also of concern. Inadequate or excessive weight gain, spontaneous abortion, intrauterine growth restriction, preterm delivery, and low birth weight, among other adverse outcomes, have been reported in pregnant women with eating disorders and their offspring. The chapter includes an important case study, six informative tables, and close to 100 relevant references.

Chapter [15](#) describes the risks associated with diabetes both before and during pregnancy. We learn that diabetes mellitus is the most common complication in pregnancy affecting nearly 8% of all pregnancies. Nearly 90% of women with diabetes develop the condition during pregnancy (gestational diabetes mellitus); the other 10% preceded the pregnancy. Perinatal mortality rates for women with diabetes have decreased with insulin use; however, infant morbidity remains higher than in the nondiabetic pregnant women. Although the dietary recommendations for diabetic women who become pregnant are the same as those for nondiabetic pregnant women, there are medical nutrition guidelines to help reduce maternal and fetal risks. The goals of medical nutrition therapy for pregnancy and diabetes are to provide adequate nutrients for maternal-fetal nutrition, to provide sufficient calories for appropriate weight gain, and to achieve and maintain optimal glycemic control.

Another unique topic included in this comprehensive volume examines the nutritional needs of incarcerated pregnant women. Chapter 16 reviews the data from the William & Mary Healthy Beginnings Project, a nutrition intervention program developed for pregnant incarcerated women in southeastern Virginia. Assessment of this program suggests that through the development of protocols and policies that consider the health-related needs of pregnant women, correctional facilities could play a pivotal role in helping incarcerated women develop healthier habits to better care for themselves and their newborns. Currently, there are about 100,000 women incarcerated in the USA or 10% of the incarcerated population. Of these women, about 10% are pregnant at any one time. Thus, in virtually all sites of incarceration policies and procedures are developed to meet the needs of the majority of prisoners who are male and not pregnant women prisoners. The chapter reviews the profile of many incarcerated women that includes drug abuse and sexually transmitted disease, lack of contraception, poor diet, and low educational level. Pregnancy is often unplanned and prepregnancy health status would suggest an at-risk pregnancy even if the woman was not incarcerated. The authors' Project is described: close to one-third of the participants in this program discovered they were pregnant upon entering the jail facility. This was a direct result of the pregnancy tests provided by the William & Mary Healthy Beginnings Project. Because these women were identified early, they were able to receive prenatal vitamins and timely prenatal care, as well as nutrition counseling and additional support to help them plan for their pregnancy. Moreover, results show participants' nutrition and pregnancy-related knowledge increased from pre- to post-counseling, and this increase in knowledge was associated with positive birth outcomes.

Chapter 17, the last chapter in Part III, looks at the effects of clinical depression during pregnancy and lactation and examines the potential for yoga to reduce the depressive episodes. In the USA, approximately 13% experience a major depressive disorder during pregnancy. There are numerous adverse outcomes associated with maternal depression for the infants, including preterm birth and low birth weight. Symptoms of depression or a clinical diagnosis of depression during pregnancy increase the risk for postpartum depression that can disrupt a mother's functioning and, in some cases, create significant difficulties with mother-infant bonding and interactions which may adversely affect the long-term cognitive and developmental outcomes during childhood and beyond. The chapter reviews the current literature and suggests that prenatal yoga classes can be of value to women who have depressive episodes during pregnancy.

Part IV contains two chapters that examine the nutritional needs during lactation and the nutritional risks associated with postpartum depression. The purpose of Chap. 18 is to provide an overview of the significant energy demands of lactation, as well as include a select list of nutrients known to be in short supply for a majority of reproductive-age women from developed countries. The specific nutrients examined include calcium, vitamin D, folate, vitamin B12, long-chain polyunsaturated fatty acids, and iron. Foods as well as supplemental sources of these key nutrients are enumerated. The chapter also reviews the literature concerning dieting and exercise during lactation. We learn that maternal deficiency of some nutrients can

adversely affect the concentration of these nutrients in breast milk. These nutrients include thiamin, riboflavin, vitamin B6, vitamin B12, choline, vitamin A, vitamin D, selenium, and iodine. In contrast, the content of folate, calcium, iron, copper, and zinc in breast milk is not directly linked to maternal status or intake and maternal sources are secreted into breast milk at the expense of maternal nutrient status. The chapter contains over 170 relevant references and 7 helpful tables. Chapter [19](#) examines the nutritional factors involved in postpartum depression. Postpartum depression is a major depressive episode, which has a duration of at least 2 weeks. Women experience either depressed mood or a loss of interest or pleasure in activities. For psychiatric diagnosis, women must experience at least four other symptoms including changes in appetite or weight, sleep and/or psychomotor activity; decreased energy; feelings of worthlessness or guilt; difficulty thinking, concentrating, or making decisions; or recurrent thoughts of death or suicidal ideation, plans, or attempts. Although the onset of this disorder is usually within the first 4 weeks after delivery, clinicians and researchers both attest to this time criterion as being much too limited. Postpartum depression generally occurs during the first 12 months; however it has been identified as late as 18 months after the birth of an infant. The chapter reviews the roles of macro- and micronutrients that affect brain function and the requirements for these in women with postpartum depression.

The last part of the book, Part V, contains three chapters that look at issues of nutrition and pregnancy from a global perspective. Chapter [20](#) discusses the issue of diabetes in pregnant women as this disease is becoming one of the most common health complications of pregnancy globally. Diabetes in pregnancy is defined as pre-existing type 1 diabetes, type 2 diabetes, and gestational diabetes mellitus (GDM). GDM involves carbohydrate intolerance of varying degree of severity with onset of first recognition that happens during pregnancy. In some cases, GDM may actually be identified as undiagnosed pre-existing type 2 diabetes. Determination of the global prevalence of diabetes in pregnancy is difficult as there are no standard definitions and diagnostic criteria; however it appears that prevalence is increasing globally which correlates with increases in female obesity. The specific problems seen in low- and middle-income countries that result in adverse pregnancy outcomes are reviewed in Chap. [21](#). Common themes across countries include teen pregnancy, preconceptional malnutrition—either undernutrition or overnutrition, lack of access to essential nutrient food sources and/or supplements, poor sanitation and other aspects of poverty, political instability resulting in high stress, and lack of medical care and/or consistent access to medical monitoring during the entire pregnancy. Maternal iron deficiency anemia is directly linked to maternal mortality in the countries examined in this chapter. Preeclampsia is linked to calcium deficiency and supplemental calcium decreases this risk but the provision of calcium to prevent preeclampsia is not universal. The final chapter, Chap. [22](#), examines the serious consequences of domestic violence to the pregnant woman and her fetus, neonate, and growing child and uses Nepal as an example. Domestic violence during pregnancy is documented as a significant public health issue linked with adverse health outcomes for the newborn including low birth weight and preterm birth. The prevalence of violence experienced by pregnant women ranges from 0.9% to 20.1% in

different societies. Violence during pregnancy accounts for approximately 15% of all gender-based violence cases in Nepal. The estimated incidence of low birth weight is 16% globally, 19% in the least developed and developing countries, and 7% in developed countries. The prevalence of low birth weight, mainly an outcome of maternal undernutrition, is relatively high in Nepal, ranging from 14% to 43%, and it is a major public health concern. Birth weight is a major predictor of infant growth and survival, and low birth weight is linked with early mortality and morbidity. It is documented that women who experienced any type of abuse—physical, sexual, or emotional—during pregnancy are more prone to give birth to a baby with lower birth weight than non-abused women. Domestic violence during pregnancy interferes with the nutritional status of women, leading to suboptimal baby weight gain. The adverse consequences of violence during pregnancy on birth outcomes are well documented. In Nepal 93% of women were exposed to mental and emotional torture, 82% were beaten, 30% were raped, 28% were forced into prostitution, and 64% reported polygamy. These terrible statistics are of great concern as it appears that mistreatment of women is an accepted part of the culture and that domestic violence continues during pregnancy resulting in serious adverse effects to both mother and unborn child. The cultural conditions linked to the continuation of domestic violence are thoughtfully discussed; however there is no simple, quick fix and thus this final chapter highlights some of the most complex factors involved in reducing the risks of adverse pregnancy outcomes in this twenty-first century.

Conclusions

Of importance to obstetricians, gynecologists, pediatricians and related physicians, nutritionists, dieticians, researchers, nurses, and allied health professionals who provide advice concerning diet, foods, nutrition, dietary supplements, and clinical management of women of reproductive age, those planning pregnancy, women who are pregnant and/or lactating, and especially women who are at risk for adverse pregnancy outcomes is the identification of objective and reputable sources of nutrition information. “Handbook of Nutrition and Pregnancy, Second Edition,” edited by Carol J. Lammi-Keefe, Sarah C. Couch, and John P. Kirwan, provides 22 valuable chapters that review and integrate these relevant and objective resources. The volume examines the major dietary patterns that have been identified as containing the components of a healthy diet especially during the reproductive years and contrasts these with dietary patterns documented in many populations of women around the globe whose access to safe foods and clean water is seriously lacking. Moreover, the volume includes extensive reviews of the key nutrients associated with normal embryonic and fetal development as well as maintaining the nutritional status of the pregnant woman. Many chapters emphasize the critical importance of adequate dietary intakes in women who enter pregnancy with medically relevant physical and/or mental issues.

This comprehensive volume examines patient-related topics including chapters on vegan and other vegetarian-based diets, the major changes in physiology that occur during normal and medically challenged pregnancies, the importance of consuming clean foods and maintaining their safety during food preparation and storage, the potential for adverse pregnancy outcomes associated with certain lifestyle factors such as smoking, alcohol, and unlawful drug use, and teen as well as older age pregnancies. Topics included in this comprehensive volume include the epigenetic consequences of folate and related B vitamin deficiencies and the adverse outcomes seen with deficiencies of iron, iodine, and vitamin D. Weight management prior to pregnancy and the consequences of being overweight or obese during pregnancy with potential diabetes, heart, liver, and kidney diseases affecting both the mother and child as well as the risks and benefits of weight reduction surgery are reviewed in depth. Unique chapters look at the global consequences of nutritional deficiencies that may be the result of population-wide lack of healthy and safe food, the result of domestic violence, and/or the effects of pathological conditions such as anorexia that compromise the nutritional status prior to as well as during and following pregnancy.

The volume contains over 70 data-rich tables and figures and appendices as well as 1900 up-to-date and relevant references that give physicians and health providers important tools that can help to improve patient dietary habits that may be less than ideal. There are more than a dozen chapters that provide clinically relevant information on risk reduction of the major adverse effects associated with conditions such as diabetes, postpartum depression, and issues of lactation. The 22 chapters within this valuable volume provide a wealth of timely information for health providers, medical students, graduate students, nurses, dietitians, and other related health professionals. Hallmarks of all of the chapters include complete definitions of terms with the abbreviations fully defined for the reader and consistent use of terms between chapters. Useful features of this comprehensive volume include the informative Key Points and Key Words that are at the beginning of each chapter and relevant references at the end of each chapter and a comprehensive index.

In conclusion, “Handbook of Nutrition and Pregnancy, Second Edition,” edited by Carol J. Lammi-Keefe, Sarah C. Couch, and John P. Kirwan, provides health professionals in many areas of research and practice with the most up-to-date, organized volume on the clinically researched and documented healthy dietary patterns that are linked to reducing the risks of adverse pregnancy outcomes for both the mother and child. Of great importance, major topics such as prepregnancy obesity, diabetes, and less than optimal nutritional status are presented so that the health provider can communicate from a position of facts and data to help assure the patient of the value of their care. Thus, the data provided in this book enables the reader to answer their patient or client questions with the confidence that their answers are based upon the totality of the evidence from well-accepted, data-driven nutrition research. This volume serves the reader as the benchmark in this complex area of interrelationships between the major dietary patterns that have been associated with reducing pregnancy-related risks. Drs. Lammi-Keefe, Couch, and Kirwan are applauded for their

efforts to develop this volume with the firm conviction that nutrition research serves as an essential source of important data for all health professionals. This excellent text is a very welcome addition to the Nutrition and Health series.

Morristown, NJ, USA

Adrienne Bendich

About the Series Editors



Adrienne Bendich, PhD, FASN, FACN has served as the “**Nutrition and Health**” Series Editor for more than 20 years and has provided leadership and guidance to more than 200 editors who have developed the 80+ well-respected and highly recommended volumes in the Series. In addition to *Handbook of Nutrition and Pregnancy, Second Edition*, edited by **Carol J. Lammi-Keefe, Sarah C. Couch, and John P. Kirwan**, major new editions published in 2012–2018 include:

1. **Dietary Patterns and Whole Plant Foods in Aging and Disease**, edited as well as written by Mark L. Dreher, Ph.D., 2018
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Dr. Bendich is President of Consultants in Consumer Healthcare LLC and is the editor of ten books including *Preventive Nutrition: The Comprehensive Guide for Health Professionals, Fifth Edition* coedited with Dr. Richard Deckelbaum (www.springer.com/series/7659). Dr. Bendich serves on the Editorial Boards of the *Journal of Nutrition in Gerontology and Geriatrics* and *Antioxidants* and has served as Associate Editor for *Nutrition* the international journal; served on the Editorial Board of the *Journal of Women's Health & Gender-based Medicine*; and served on the Board of Directors of the American College of Nutrition.

Dr. Bendich was Director of Medical Affairs at GlaxoSmithKline (GSK) Consumer Healthcare and provided medical leadership for many well-known brands including TUMS and Os-Cal. Dr. Bendich had primary responsibility for GSK's support for the Women's Health Initiative (WHI) intervention study. Prior to joining GSK, Dr. Bendich was at Roche Vitamins Inc. and was involved with the groundbreaking clinical studies showing that folic acid-containing multivitamins significantly reduced major classes of birth defects. Dr. Bendich has coauthored over 100 major clinical research studies in the area of preventive nutrition. She is

recognized as a leading authority on antioxidants, nutrition and immunity and pregnancy outcomes, vitamin safety, and the cost-effectiveness of vitamin/mineral supplementation.

Dr. Bendich received the Roche Research Award, is a *Tribute to Women and Industry* Awardee, and was a recipient of the Burroughs Wellcome Visiting Professorship in Basic Medical Sciences. Dr. Bendich was given the Council for Responsible Nutrition (CRN) Apple Award in recognition of her many contributions to the scientific understanding of dietary supplements. In 2012, she was recognized for her contributions to the field of clinical nutrition by the American Society for Nutrition and was elected a Fellow of ASN. Dr. Bendich is Adjunct Professor at Rutgers University. She is listed in *Who's Who in American Women*.



Connie W. Bales, PhD, RD is a Professor of Medicine in the Division of Geriatrics, Department of Medicine, at the Duke School of Medicine and Senior Fellow in the Center for the Study of Aging and Human Development at Duke University Medical Center. She is also Associate Director for Education/Evaluation of the Geriatrics Research, Education, and Clinical Center at the Durham VA Medical Center. Dr. Bales is a well-recognized expert in the field of nutrition, chronic disease, function, and aging. Over the past two decades, her laboratory at Duke has explored many different aspects of diet and activity as determinants of health

during the latter half of the adult life course. Her current research focuses primarily on enhanced protein as a means of benefiting muscle quality, function, and other health indicators during geriatric obesity reduction and for improving perioperative outcomes in older patients. Dr. Bales has served on NIH and USDA grant review panels and is Past-Chair of the Medical Nutrition Council of the American Society for Nutrition. She has edited three editions of the *Handbook of Clinical Nutrition and Aging*, is Editor-in-Chief of the *Journal of Nutrition in Gerontology and Geriatrics*, and is a Deputy Editor of *Current Developments in Nutrition*.

About the Editors



Sarah C. Couch, PhD, RD is a professor and Director of the Graduate Program in Human Nutrition in the Department of Rehabilitation, Exercise and Nutrition Sciences at the University of Cincinnati. She has an MS and PhD in nutritional sciences and is a registered dietitian specializing in evaluating dietary approaches in the prevention and management of cardiovascular disease risk factors. Dr. Couch has conducted human subject research for over 20 years, specifically examining dietary assessment approaches and dietary patterns related to cardiovascular disease risk reduction, and has authored over 65 peer-reviewed publications. She is a previous recipient of a grant award from the National Heart, Lung and Blood Institute to examine the effi-

cacy of a DASH dietary pattern delivered as part of a clinic-based behavioral nutrition program for the management of elevated blood pressure in adolescents. Her studies have also involved assessment of the home food environment as a potential modifiable risk factor related to childhood obesity and CVD risk. Her particular interests related to the home environment are parenting style and child feeding practices and parent and adolescent food literacy in relation to diet quality and weight status.



John P. Kirwan, PhD, MSc is Director of the Metabolic Translational Research Center and Professor of Molecular Medicine at the Cleveland Clinic in Cleveland, Ohio, USA. He is also a Professor of Nutrition, and of Physiology, at Case Western Reserve University School of Medicine in Cleveland. His professional expertise includes almost 30 years of research, teaching, and service in the obesity, diabetes, and nutrition fields. Dr. Kirwan received his clinical physiology training at Washington University School of Medicine in St. Louis, Missouri; his PhD in human bioenergetics at Ball State University, Muncie, Indiana; his MSc in

exercise biochemistry from the University of Massachusetts, Amherst, Massachusetts; and his BA (Hons) from the University of Limerick, Ireland.

Dr. Kirwan leads an internationally acclaimed biomedical research program focused on diabetes, obesity, nutrition, and exercise. To date he has generated over \$35 million in research funding, most of which has come from the US National Institutes of Health, and the food, pharmaceutical, and medical device industries. He has published over 200 scientific papers related to metabolism and nutrition in prestigious peer-reviewed journals including the *New England Journal of Medicine*, *JAMA*, *Diabetes*, and the *American Journal of Clinical Nutrition*. Among his most important research contributions is the discovery that, for a significant number of patients, diabetes can be cured by surgically altering the physiology of the intestine and stomach.

He is married to his wonderful, brilliant wife April, has 4 fantastic children, and plays “Dad” to a lovable mutt named Bailey!



Carol J. Lammi-Keefe, PhD is Alma Beth Clark Professor of Nutrition, School of Nutrition and Food Sciences, Louisiana State University, and Adjunct Professor at the Pennington Biomedical Research Center, Baton Rouge, Louisiana.

She has devoted more than three decades to research in maternal and fetal nutrition, with an emphasis on lipids and especially omega-3 fatty acids. Her research findings include the benefit of docosahexaenoic acid during pregnancy on infant functional outcomes, including sleep, visual acuity, problem solving, and decreased adiposity. A current federally funded project will assess the benefit of omega-3 fatty acids in decreasing the

inflammatory response in overweight pregnant women and the effect on infant adiposity.

Her research findings have been published in journals including the *American Journal of Clinical Nutrition*, the *Journal of the American Dietetic Association*,