

OXFORD MONOGRAPHS ON MEDICAL GENETICS

GENOMICS AND HEALTH IN THE DEVELOPING WORLD

EDITED BY
DHAVENDRA KUMAR

OXFORD

**GENOMICS AND HEALTH
IN THE DEVELOPING WORLD**

OXFORD MONOGRAPHS ON MEDICAL GENETICS

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EDITED BY

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“To millions of people in the developing world who live with poverty, hunger and disease”

“Science to be science must afford the fullest scope for satisfying the hunger of body, mind and soul”

– Mahatma Gandhi

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PREFACE

Health of any nation depends upon its sound economic base, political stability, healthy agriculture (crops/animal stock), a safe environment (clean water, sanitation and climate control) and the general well-being of its peoples. Among several biological and ecological factors, the role of genetics and genomics is now widely accepted as a major determinant for the health of a nation. There are diverse and far reaching applications of genetics and genomics that we are beginning to utilize in all walks of life, including genetically engineered vaccines and biological products (insulin and growth hormone), new drugs (cancer and heart disease), genetically modified crops (enhanced produce and biofortification), developing bioengineered vectors for controlling malaria and other parasitic diseases, and the preservation of animal and plant life (rare and extinct species).

Most developed nations in the West have invested, and continue to do so, in harnessing the benefits of genetics and genomics. However, large populations in the less developed and least developed countries—comprising more than two-thirds of the world's population—continue to be deprived of potential health and socioeconomic applications (Figure 1). It is estimated that the current global population of around 7 billion will rise to around 10 billion by 2050 (Figure 2). There is concern that currently around 5 billion people are deprived of the benefits of modern science and technology, including genetics and genomics.

The clinical use of medical genetics and human genetic research is concentrated in the developed nations of Europe and North America that cover less than one billion people. In contrast, India alone has over 1 billion people equally at risk for being affected with a wide range of genetic diseases! The volume and burden of genetic disease afflicting those in other, developing or less developed or “low income” countries are beyond both imagination and comprehension. In addition to medicine and health, whole nations and peoples are being deprived of the socioeconomic benefits from investment and infrastructure developments in areas like biomedical and agriculture technology. The current and future applications of genome science and technology in pharmaceutical, bioengineering, and the food and agriculture industries hold great promise for the new emerging economies of

the developing world (Juma and Yee-Cheong, 2005). This challenge offers new opportunities for promoting international cooperation in relevant biomedical research in developing countries as recommended by the United Nations' Millennium Project Task Force on Science, Technology and Innovation (UN Millennium Project Report, 2005). These recommendations are included in the UN Millennium Development Goals (Acharya et al., 2003).

Since the completion of mapping/sequencing of the human genome and other genomes, rapid progress has been made in a number of areas of biomedical research and biotechnology. Biotechnology has emerged as one of the methods that can be used to address health and other socioeconomic challenges in developing countries (Acharya et al., 2003). This largely depends upon the development of infrastructure and adopting a diverse set of policies aimed at translating scientific discoveries into goods and services. These technologies include molecular diagnostics, recombinant vaccines, techniques of vaccine and drug delivery, bioremediation (use of living organisms to degrade hazardous matter), sequencing pathogen genomes, female-controlled protection against sexually transmitted infections, bioinformatics, nutritionally enriched genetically modified crops, recombinant therapeutic proteins, and combinatorial chemistry (Daar et al., 2002).

While it is necessary to prioritize the current limited resources in dealing with the most common socioeconomic and health problems faced by developing countries, especially the least developed countries, resulting from poverty, malnutrition, unsafe water supply, poor sanitation, and communicable diseases, it is nevertheless important to invest in new science and technology to bridge the gap and prepare some ground for future developments. Unfortunately, geographic, economic, and political challenges in these countries often restrict investment and improvement in the infrastructure development necessary to sustain progress in any area. There is ample evidence to argue that genetic and genomic factors play an important role in the causation of the common health problems affecting developing and least-developed nations, and in their consequences for these populations. This issue was examined and highlighted in the WHO

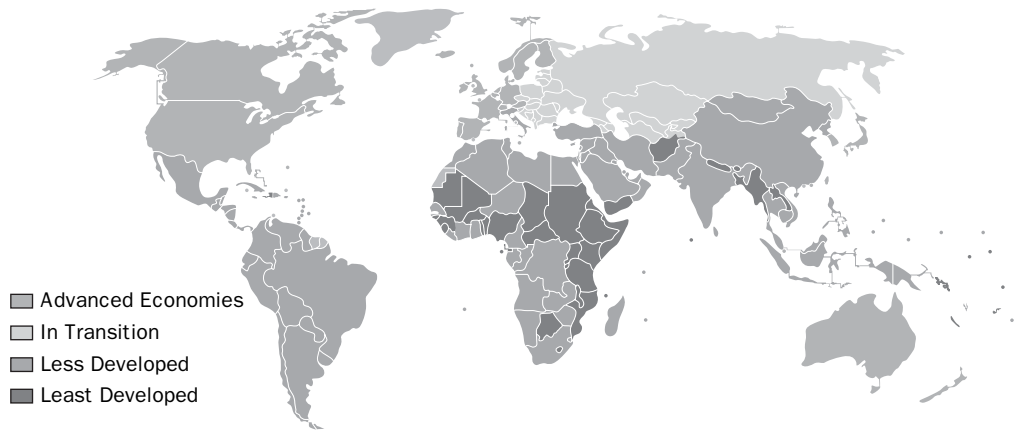


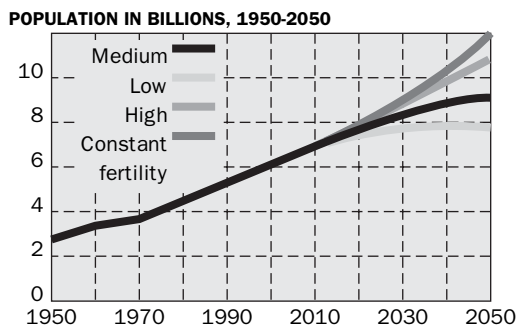
Figure 1 The world map showing least and less developed nations including those in transition.

expert committee report on role of genomics for global health (WHO, 2002). This has been followed by several reports and publications that lend further support to the view that the developing nations in Asia should not be left behind in acquiring relevant genetic and genomic technologies for the betterment of health. A recent editorial commentary (*Nature*, 2007) points to this subject and sets out an optimistic picture of the future of genetics and genomics in developing countries, particularly India, Latin America, the Arab world, and parts of Africa. The importance of genetics and genomics is acknowledged in the recent WHO statement on the global prevention of birth defects endorsed by the Sixty-Third World Assembly (WHO, April 2010). The WHO ‘Grand Challenges’ project on applications of genomics in the public health in the developing world (July 2011) is expected to identify potential areas and offer strategic guidance to member Nations in the developing world.

The practice of clinical medicine in public health is rapidly changing in the light of recent critical advances in genetics and genomics. This is largely based upon the sequencing of the human genome and a number of other genomes, including agricultural crops and other plants, as well as pathogens and important model organisms

(microbes, worms, insects, and mammals). The true extent of the power of genomic science and technology in shaping and influencing medicine and the economy is difficult to describe but is likely to be vast. There are now several dedicated publications and on-line resources specifically reporting and discussing this subject. The publication of this book is timely, and we hope that the reader will find the insights presented throughout the volume to be exciting, challenging, and constructive. In addition, the book contains information that will be helpful beyond the confines of the profession of medicine, including the range of those with responsibility for making decisions on biotechnology development and health planning, and those concerned with related social, ethical, economic, and legal matters.

There is no single book that deals with the issues and challenges for the emerging economies of the developing world in confronting the rapid advances of genome science and technology. This is probably the first book providing a detailed and comprehensive account of this extremely important field, and it is likely to have a major impact on healthcare and the economy in most countries in the developing and least-developed world. There are a few volumes currently available that cover selected population groups only, for example Jewish peoples (Abel, 2001) and peoples of African descent (Bowman and Murray Jr., 1998). There are only two books that cover in some detail the human genetics of the Arab world (Teebi and Farag, 1996) and the populations of the Indian subcontinent (Kumar, 2004). It is anticipated that the publication of this new book will fill a huge gap that currently exists in information and issues about human health in those countries that constitute the newly emerging and other developing economies of the world. It is now widely believed that the rapid development and inclusion of genetic and genomic technologies will be crucial to any nation’s socioeconomic well-being, and the health of its population. It is important that this technology and expertise should not remain beyond the reach of the developing world, confined to the



Source: United Nations

Figure 2 The United Nations projection of the global population.

global West and North. We hope that the structured presentation of factual information in this book will serve as a useful resource for a wide range of professionals in medicine, population health, the biotechnology industries, media, and public services.

The book is expected to be useful to a broad range of audiences including practicing and trainee medical practitioners, health professionals, human genetic scientists, medical geneticists, genetic counselors, public health physicians and consultants, experts in health economics, bioethics, sociology, anthropology, and others leading various projects at national and international levels. The book includes material that is also applicable to medical and related professionals about the minority migrant or resident ethnic populations working and living in the developed countries of Europe and North America, as well as Australasia.

This “multi-author” edited book includes several expertly written chapters providing a detailed and comprehensive account on most aspects of population and human genetics, with an emphasis on medical and health issues related to a defined geographic region and, as far as possible, covering all major ethnic groups. The book is set in two parts, each part with several chapters contributed by a panel of internationally renowned experts in the designated field or area of interest. The first part covers general aspects of population origin and heterogeneity, an introduction to basic genetics and genomics, and the principles of human genetics, the classification of human disease from genetic and genomic perspectives, the current and future health strategies in dealing with the common human genetic diseases affecting developing countries, social and cultural practices and legislation pertinent to human genetics and genomics, the impact of genomics on human health in the developing world, and the related social, ethical, economic, and legal issues. The second part gives an account of selected genetic disorders and the genetic services relevant to major geographic and population-specific regions. Chapters within each section are written and carefully edited with the advice of experts with specialist knowledge and understanding of the subject and related regional and ethnic issues.

This book is only a small effort by several dedicated professionals, who share the commitment and strong belief that the applications of genome science and technology are crucial for the socio-economic development and provision of modern healthcare to large heterogeneous populations in the developed and least-developed nations of the world. Hopefully, it will be a contribution, however small, to achieving the goals of the World Health Organization and that of emerging low- and middle-income economies across the world.

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FOREWORD I

The past one hundred years has seen the remarkable rise of science and medicine in the West. The great public investments in biomedical research and technology by the developed economies have not only contributed to the vastly improved health of their citizens, but that knowledge and its practice has, in no small measure, contributed to the improved health of populations in the developing economies as well. It is now an expectation, of people and their governments, that investments in science and medicine should improve health in their lifetimes. For someone like myself, who started academic life merely interested in the mysteries that genes offered, and who has found himself in the rapidly advancing biomedical field of human genetics, this last statement is extraordinary but possibly realizable.

We are likely in the midst of another major revolution in medicine occasioned by the human genome sequence. The rise of genetics and genomics has not only produced a common intellectual (and intelligible) language for the biomedical sciences, but has raised huge expectations that we can rationally understand the molecular causes of any human disease, create efficient diagnostic tools, and invent rational chemical therapies. More importantly, genomics has added a new dimension to medical practice, raising the expectation that we might be able to “personalize” treatment to the individual patient. Will the transfer of this new science and health knowledge, from the developed to the developing countries, be the same as that in the past? There are many reasons to suspect that it will not, and this edited volume by Professor Dhavendra Kumar is an argument for this view. Three major underlying themes in his book deserve mention.

First, genetics explains our individuality and how our recent shared human ancestry affects the variation in our genomes. Consequently, there is no full understanding of a human disease, not even a purely single-gene Mendelian disorder, from studying patients in one geographical locale. Alternatively, a comparative study of the same

disease across cultures, ecologies, and ancestries is more informative for all patients. Second, unique cultures often produce unique genetic outcomes not always observed elsewhere. This could include the occurrence of consanguinity, or unique diets and lifestyles, and have effects on the distribution of the types and nature of genetic mutations. If we are to understand gene–environmental interactions it is quite clear that we will need a global study. Third, modern genetic and genomic technologies, ever since the recombinant DNA days, are powerful primarily because they are “species-independent” and can be of great benefit not only to medicine but also to agriculture and veterinary applications. This has not escaped the notice of many governments who are now enthusiastic about their investments in “biotechnology.” Consequently, and despite the differing magnitudes of investment, many developing nations think it in their self-interest to develop biotechnology for solving health problems unique to their lives.

Genomics and Health in the Developing World is a potpourri of chapters that attempts to educate us to the nature, magnitude, successes, and opportunities for genetic studies in the developing world. Individually, the chapters inform us about the current state of the art. Collectively, the chapters demonstrate that a true understanding of the problems of genetic disease and personalized genetics will require solid and persistent contributions from the developing world.

We all live in a remarkable time in biomedicine, where each human has something credible to contribute to humanity’s understanding of health and disease, and the practice of medicine. Whether you are a student or teacher, geneticist or not, researcher or health professional, you will find this treasure exciting.

Aravinda Chakravarti, PhD
Baltimore, MD
December, 2011

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FOREWORD II

Because of the extremely high childhood mortality in the poorer countries of the world resulting from malnutrition, limited public health services, and the ravages of communicable disease, international health agencies have tended to ignore the growing importance of congenital malformation and genetic disease as an emerging global health problem. In 2006 the American charity, March of Dimes, in its *Global Report on Birth Defects* estimated that more than 7,000,000 babies are born each year with either a congenital abnormality or genetic disease, and that up to 90% of these births occur in low- or middle-income countries. Remarkably, over 25% of them consist of only five conditions: congenital heart defects, neural tube defects, inherited disorders of hemoglobin, Down syndrome, and glucose-6-phosphate dehydrogenase deficiency. Overall, however, over 7,000 birth defects of genetic or partial genetic origin have been identified.

There are several reasons why there is a higher frequency of births with these conditions in the poorer countries. They include natural selection, a high frequency of consanguineous marriages, increased maternal age, and the effects of the epidemiological transition whereby, as public health measures and improved standards of living reduce childhood mortality rates, many babies who

would have died with genetic disorders are now surviving long enough to present for diagnosis and treatment.

It is clear, therefore, that genetic disease cannot continue to be ignored by governments of the developing countries or by the international health agencies. One of the major obstacles toward progress in this field is lack of accurate global data about the frequency of these conditions, and current facilities for their diagnosis and management. In this book, many aspects of the current background to the high frequency of genetic disease in the poorer countries are explored, together with representative accounts of the problems raised by genetic disease in many of these countries. It is hoped that information of this type will form the basis for educating governments and health agencies about the increasing problems that genetic disease will pose in the future, particularly in countries that are going through the epidemiological transition with falling childhood mortality rates. This is a critically important topic for the future of global health-care, and I wish this book all the success it deserves.

D.J. Weatherall, FRS
Oxford
September 2011

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