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# Genomics, medicine and public health

Alexander M. Trbovich

*Institute for Medical Research, University of Belgrade, Belgrade, Serbia and New Cardio, Menlo Park, CA, USA*
*Correspondence to Alexander M. Trbovich, Institute for Medical Research University of Belgrade, Dr. Subotica 4, P.O. Box 102, 11129 Belgrade, Serbia. E-mail: Aleksa11@email.com*

## Abstract

Public health genomics unifies the scientific disciplines of genetics and public health. Public health genomics aims to facilitate the transfer of newly acquired knowledge in genetic and molecular biology into classical medicine, to evaluate the currently available genetic tests, and to educate both the medical community and the general population about advancements in molecular and cell biology of medical interest. Due to various factors, the application of new genetic discoveries in classical medicine and the evaluation of the current genetic clinical tests occur at relatively slow paste. The challenge of public health genomics is to create the most effective modus for coexistence of new molecular and cell biology discoveries and classical medical techniques in applied medicine. The ultimate goal is to accomplish a truly individualized medical therapy.

*Key words: genetics, public health genomics, individualized therapy, medicine, public health, education*

### Genomics, medicine and public health

Genetics is a science of heredity that studies genes and their variations, functions, interactions and modes of inheritance. In contrast to genetics, which tends to focus on understanding a particular gene, genomics is a comprehensive study of an entire set of genes (genome) that belong to a certain individual or an organism. An all-embracing application of genetics towards the advancement of public health should be a key priority of public health practitioners. Certain medical conditions can be addressed from different perspectives, such as psychiatric, physiological or genetic. The genetic approach is the most basic but also the least understood by modern day physicians. Physicians tend to study medical genetics as they study medical physics, rarely applying the acquired knowledge during the course of their careers. They learn basic genetics, but not the tests and the tools required to translate that knowledge into practice. There are several reasons for this. Firstly, there is a certain level of resistance expressed by "old school" physicians who were not trained in genetics but who continue to be charged with training young physicians in practical medical skills. Secondly, geneticians, who are not physicians by training, tend to focus on specific genetic regulation rather than on the patient as a whole. Finally, the general-public fears the genetic approach in medical treatment, which stems from general xenophobia, fear of the unknown. The challenge for public health practiotioners would be to bridge the present misunderstanding and enable the full implementation of genetics into practical medicine. To complete the task successfully, they need to understand basic genetics. Otherwise, public health practitioners could themselves become an obstacle to the wider implementation of genetics in medicine. Yet, at present public health practitioners do not receive training in genetics [1] but seek and attend courses individually about basic genetics and other, so called "popular science" genetic courses.

A knowledge of genetics, by public health practitioners, is a prerequisite for public health genomics to be widely accepted as a method, inducing other medical fields to implement genetic based tests and treatments in order to provide truly individualized and thereby more successful medical therapies. [2]

### Genetics and digitalization in medicine

While genetics has been in use in some forms in several medical fields for decades, its application has been exceptional, rather than the norm. It is considered to be just another medical test out of the many available in order to obtain the correct diagnosis. At present, genetics is in use in pediatrics (chromosomal aberration, inherited enzymatic disorders), prenatal consulting (predisposition for obtaining certain hereditary disorders), transplantation (mismatch of the donor and recipient of organ), hematology (disorders of hemostasis, white cell immunologic disorders), forensic medicine (DNA evidence), etc. The obstacle to the general acceptance of genetics as a medical tool possibly lies in the fact that it overlaps with another revolution in medicine – digitalization. We

have all witnessed the conversion from paper and printed X-ray data to digital medical records, and the evolution of many medical devices, including thermometers to a digital version. Nonetheless, once digitalization is more widely implemented, it will also enable the greater use of genetics across all fields of medicine. Just as many people might not have perceived the benefits to digitalization some time ago, today they may not see a need for genetic testing. They fear the same things – controlling people and their future by use of computers, medical cloning or simply by possessing important information about them.

### Genetics and ethics

It is expected that genetics will change medicine just as the industrial revolution, electrification or present day digitalization has changed the world. As with any revolution there could be undesired side effects, such as good devices becoming obsolete. In medicine, genetics have already lead to new ethical questions. The debate has spread to the general society, polarizing lay persons who have formed opinions based on their emotions rather than knowledge. One of the issues concerns cloning. Certainly, the public should be better educated about cloning in order to distinguish between the more questionable human cloning and cloning that yields new therapeutic drugs, such as recombinant human insulin that prevents the undesired immune response in the recipient. Possession of somebody's genomic data is another issue. Health care insurance companies would be able to determine premiums according to insurer's genetic blueprints. Preparedness of today's society to regulate these issues, influenced by the ability of public health practitioners to correctly present the relevant information to the general public, will determine the future of public health genomics. [2] One must also be aware that many genetic tests and devices have not yet been standardized, that genetics may overemphasize the importance of some data, and that we still cannot fully explain some results. However, there is room for optimism in this regard, considering that many technically troubling issues have already been settled. At the very end, genetics may not give all the answers to all the questions, and not all genetic variants will turn out to be of practical significance, but we have to accept the fact that genetics offers the best approach to the individualization of medical therapy, which is the ultimate goal of medicine.

### Basic genetics

Applicable genetics of the present are not the same as applicable genetics of the past. We all know Mendel's laws of inheritance [3], which this scientist established without knowing what genes were. With the passage of time, we discovered that chromosomes consist of DNA wrapped around certain proteins and that genes were a part of that DNA [4]. One also learned that human DNA consists of 3 billion base pairs of G, A, T, and C [5]. It was much more difficult to discover what base pairs make up a gene, and to define the surroundings of a gene. We still do not know precisely how many genes there are in humans (between 20,000 and 25,000), but we know how to distinguish them from the rest of the sequences. The sequences surrounding the genes, which did not code for proteins, were initially considered useless and called "junk DNA" [6]. Today we know that at least some parts of that "junk DNA" represent regulatory sequences for the genes and that genes do not make up more than 5% of total DNA [5]. We are also aware that not all genes are expressed in every cell and that their expression depends on the structure of their regulatory sequences and availability of proteins that binds to those sequences. If a gene is expressed in a cell where it should be turned off or vice versa, this outcome may lead to cancer. To make the story more complicated, in many instances one gene codes for more than one protein due to the rearrangement of parts of genes called exons, which, for example, may occur in production of antibodies [7]. While all of our proteins are products of our genes, not all gene mutations cause differences in the structures or functions of proteins. Since proteins are ultimately responsible for the functioning of the body, a new scientific field of proteomics is emerging.

### Molecular and cellular biology

To completely understand the series of events that occurs on the path from genes to proteins, one should know modern cell physiology. It took a long time for medical knowledge to be able to move from the body physiology to the cell physiology level. The branch of science that studies cell physiology is called molecular and cellular biology. This new field unifies genetics, biochemistry, and cell biology. Instead of remaining in the realm of their rigidly defined scientific disciplines, the scientists had decided to resolve enigma of their interest by moving out of their fields of expertise to establish a new science. At present, the same step should be taken by the classically trained physicians who should embrace genetics, or the entire field of molecular and cellular biology. The aim is not to discard classical physiology but to enrich it with molecular and cellular biology. The ultimate goal would be to cure people by any means available,

since ignoring one approach in favor of another would only hurt patients. Public health genomics should, for the benefit of patients, and population health in general [2], objectively evaluate the classical physiological approach and the cellular and molecular approach, creating the most effective modus for their medical coexistence.

### Modern medicine and genetics

The benefits of the molecular and cellular approach in classical medicine are already apparent in many disciplines. For example, in microbiology it is possible to diagnose certain infectious diseases more rapidly, even with minimal amount of material.This is due to employment of a polymerase chain reaction (PCR) machine [8], which essentially multiplies DNA to create sufficient data for medical analysis. In addition, during the multiplication process, the PCR machine can connect broken parts of DNA, recreating the original DNA. A foreign DNA or RNA found with the help of PCR machine represents proof of presence of certain microbes, that is, of an ongoing infection. In addition, thanks to genetics, we are able to distinguish among different disorders that were prior to that considered to be a single disease. For example, the hemoglobin S disease (sickle-cell anemia) and the hemoglobin C disease are separate entities. Furthermore, we have become aware of the existence of another disease – hemoglobin SC disease (9). Use of genetics has also demonstrated that it is not only that one gene is translated to one or more proteins but also that certain proteins, such as hemoglobin, consist of products of more than one gene. In most cases diagnostics based on genetics tend to be faster and certainly more reliable. For instance, employment of the array-based comparative genomic hybridization in prenatal diagnostics of chromosomal abnormalities has increased the detection of this type of abnormalities relative to the risk, becoming an option for a higher level of screening in high-risk pregnancies [10]. However, genetics is not employed only in diagnostics, but also in medical treatment.The difficulty in applying genetic therapy lies in the fact that it is extremely difficult to target deliverance of a missing gene to a correct spot in the body. Various viral vectors have been used for this purpose, but still without a real breakthrough. On the other hand, the power of genetics was well illustrated in one event that occurred at the end of the 20th century. Physicians in the US then asked a biotech company that developed DNA chip and microarray technology to tell them what genes were active in patients with esophageal cancer. They had a patient with a especially lethal type of cancer and they wished to rapidly identify the best therapy. In fact, the problem with many cancer therapies is that they work with one patient but not with another. Even if those cancers histologically look alike and consequently bare the same name, they could have mutations in different genes. In the case of the patient with a lethal form of esophageal cancer, physicians could apply radiation therapy or one of many chemotherapeutic approaches. The DNA chip technology (shows activity of genes in the tissue of your choice) applied to that cancer suggested that most of chemotherapy choices, including the angiogenesis drugs that were new at the time, would not work, but that three drugs would produce positive results. In addition, this DNA approach discovered that the patient's tumor produced enormous quantities of one enzyme that happened to be the target of another experimental drug. Following successful treatment, based on genetic analysis of the tumor, the patient entered in remission [11].

### Human genome project and stem cells

Biotech companies have initiated the development of genetically tailored drugs that would act on the regulatory sequences of various genes.This was to a large extent made possible by the completion of the human genome project [5] whose aim was, as the name says, to sequence (determine the order of bases A, C, G,T) the entire human genome. Another novel medical treatment that is based on advances in cellular and molecular biology is the administration of stem cells to patients with myocardial infarction which leads to a reduction of the infarct [12]. Also, when some "classical" techniques such as liposuction do not produce the desired results, "new" techniques such as computer designed enzymatic injection could be employed. . Prevention of illness, which represents the primary goal of public health, shall improve once the new medical knowledge, available with the completion of the genome project, is more widely applied [3].

### Genetic diseases

It appears that almost all human diseases are genetic or at least have a genetic component. Infections are one of the major exceptions. However, some people have such a genetic composition that they are immune to certain lethal diseases. For instance, people with a mutation in certain receptors are immune to HIV or plague. Classic pathology recognizes a group of diseases called genetic disorders. Under genetic disorders they usually distinguish chromosomal disorders (Down's syndrome, Cri du chat syndrome etc), monogenic disorders (Huntington's disease,

phenylketonuria, cystic fibrosis etc), polygenic disorders (diabetes mellitus, hypertension, schizophrenia etc), and disorders of sexual differentiation (true hermaphrodite, male pseudohermaphrodite etc). Our intention is not to judge the correctness of that division but to point out that we know the genetic basis for many more diseases, and that genetic background should, for starters, at least be as intensively studied as the histology of a disease. Our understanding of the pathology of many diseases is now changing as it changed when classical histology was introduced. Genetics and cellular and molecular biology are providing us with different approaches to some diseases and possible therapies. It is up to the physicians to decide, on a case by case basis, which approach to use. To this end, besides understanding cellular and molecular biology, physicians should work in medical surroundings where it is possible to conduct the required testing. Public health genomics should provide that surrounding in terms of knowledge, devices and organizational structure [2].

## Individualization of medical therapy

Although a genetic approach may change the treatment of some diseases, classical surgery will probably continue to be the treatment of choice for conditions such as volvulus or in orthopedic and other cases, as well as in organ transplantation. Nonetheless, even surgery is nowadays more cost effective thanks to the introduction of minimally invasive techniques (laparoscopy etc). More advanced medicine offers more treatment alternatives and turns medicine into more complicated, but also a more democratic field. "Democratization" of the health care services coincidentally overlaps with intensified requests for more human rights and individual freedom worldwide [13,14]. It appears that medicine, with its genetic individualization of therapy, is on the right track [15]. Public health genomics can support this process by validating the new, advanced tests and techniques and by educating both the medical community and general public about them [16,17]. Public health genomics should concentrate its efforts in two areas: the application of new discoveries in genetics, and enhanced use of molecular and cellular biology in "classical" medicine. If public health genomics does not successfully fulfill these tasks, genetics could instead of advancing medicine develop into a separate, paralleled scientific field that is insufficiently linked to practical medical application.

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