



The Personalization of Disease Prevention and Intervention by Tailored Medicine and Nutrition

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Abstract

Recently developed technologies to rapidly sequence DNA will quickly advance the exciting new field of personalized medicine (PM). The now rapid availability of genomic data creates the opportunity to tailor medicine and diets to specifically complement a person's genetic makeup. PM has the potential to dramatically decrease the administration of unnecessary therapies as well as minimize side effects. Incorporation of tailored nutrition plans into genetically-based therapeutic protocols could also aid in disease prevention and intervention, but will require more research in the field. The wide variability of patient's genetic makeup must be taken into account in order to maximize response and therapeutic outcomes for a wide range of disease states. As the field of PM emerges, there is tremendous opportunity for nutrition to play a central role in both treatment and prevention.

Keywords: Nutrition; Nutrigenomics; Genomics; Personalized medicine; Metabolome

Abbreviations: PM: Personalized medicine; SNP: Single Nucleotide Polymorphism

Personalized Medicine (PM) is a tailored approach to patient medical treatment and is sweeping through the fields of medicine and science. The potential improvements in patient care and outcomes are so great that it will change the way physicians and dietitians medically treat their patients in the near future. In order for the field of nutrition to maintain vitality in the future, it must embrace and incorporate new technologies into research programs and dietetic practices. Fortunately, nutrition readily incorporates into PM through nutrigenomics and personalized diets, which are designed to prevent and intervene with disease. A combination of prevention and intervention could prove to be a powerful tool in the fight against chronic diseases [1], paving a bright future for both the field of nutrition and PM. As such, promotion of PM research in relation to nutrition and disease should be a primary function of journals and funding agencies.

The term PM is commonly used to reference the use of patient information, in this case genetic or biological, to tailor medical treatments that are specific to the characteristics of each individual. Until now, the technology to utilize PM was not conducive to effective implementation into treatment protocols. Recently this has changed with announcements by Life Technologies and Oxford

Nanapore on the development of new rapid and cost-effective DNA sequencing technologies. These technologies will allow for quick and relatively cheap access of patient's DNA information to scientists and health care providers. One such technology, the Ion Proton Genetic Sequencer created by Life Technologies, can sequence the entire human genome in one day. The machines will cost under \$150,000 and samples can be processed for around \$1,000, a price which we believe many people would be willing to pay to have their DNA sequenced. With a relatively affordable device cost of less than \$150,000, hospitals and clinics will want to make this device a standard given its potential to improve patient care and practice efficiency. Oxford Nanapore is taking device size and sequencing speed to new limits. Recently the company announced a device, the size of a thumb drive that can read DNA directly from blood, and a sequencing device so efficient and inexpensive, 20 of them used simultaneously would be able to sequence the entire human genome in 15 minutes for around \$1500. These technological breakthroughs in genomic sequencing means that cost, time and size barriers are dissolving and that implementation of PM is around the corner. The industries that embrace these genetic technologies will have the potential to forge ahead and benefit considerably, while industries not utilizing them will likely stagnate from lack of foresight.

PM will also be pushed forward by the demand for efficient treatment paths to provide cost-effective solutions in a health care industry where costs are increasing to unmanageable amounts. A report from the Hastings Center indicates patient costs associated with chronic disease are dramatically increasing. The report projects patient costs from diabetes and Alzheimer's alone to reach approximately \$ 400 billion between 2015 and 2020 [2]. Health care cost increases such as these should push the treatment paradigm toward PM, where more rational and efficient treatment protocols, like preventative medicine, can be employed. The incorporation of PM into disease treatment will eventually be a standard of care and preventive uses of PM will dominate the market place to offset the burden on healthcare budgets from sustained treatments of chronic diseases. Imagine a scenario where a physician can take a patient's blood sample and be able to identify the optimal drug for the patient's condition through almost instant interpretation of genetic makeup. Such a personalized diagnosis provides patients with more effective treatment and fewer side effects, ultimately saving precious treatment time and reducing costs. The costs saving benefits of PM extend beyond effective diagnosis to preventative medicine as well. Whole food diets provide a cost effective means to employ or complement PM through personalized diets based on nutrigenomics, with only the cost of genetic screenings and food [3]. Many possibilities exist for the application of genomics to nutrition. Consider, what foods work best to complement traditional care? What foods should be consumed to prevent disease based on a person's genetic makeup? Or possibly, what foods should not be consumed?

The ultimate goal of PM is to utilize information about a patient to prescribe medicine in a tailored approach, in which only the most effective treatments are used, thus increasing medical efficiency. In principle, medical practitioners have been using PM for quite some time. As such, a patient with a breast tumor that expresses the estrogen receptor (ER positive) may be given an estrogen antagonist,

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a drug that blocks the binding and activity of estrogen to the tumor. In contrast, there is no need to administer the antagonist to a patient whose tumor has no receptors to block. As the field of PM matures, information made available to physicians before prescribing medicine is where PM will prove most advantageous. According to the *New England Journal of Medicine*, there are currently genetic tests for 2000 disease states, increasing exponentially [4]. This eruption of knowledge will leave no choice but to renovate the way physicians treat their patients, by utilizing the wealth of personalized information that becomes available to them. The paradigm in place for the training of health care providers and dietitians will also have to evolve to meet these new and exciting advances. This undeniable merger of basic science, molecular biology, and clinical health will eventually produce physicians innately trained to implement the most novel and state of the art care. Scientists must explore the genetic correlation between genes, diet and disease, to allow physicians to understand the importance of tailored diets when developing patient treatments. Dietitians will then be able to work more effectively with physicians to incorporate diet into treatments protocols. Considering genetic variability can influence macro and micronutrient intake requirements, dietary recommendations may ultimately need to be tailored specifically to each patient, making blanket recommendations obsolete. Corbin et al. discussed the determination of optimal choline level intakes may depend on gender, estrogen status, and single nucleotide polymorphisms [5]. Additionally, Vanden Huevel discussed the effects of nutrigenetics and nutrigenomics on response to Omega-3 fatty acids and their efficacy in the prevention of a variety of diseases such as cancer and cardiovascular disease [6].

The primary challenge of PM and nutrigenomics will be acquisition of knowledge on many fronts, including building large databases of genes and their corresponding proteins, metabolites and mutations [7]. Further understanding will require discovery of how drugs and foods interact with genes and their mutations. Rudkowska recently studied the varying responses in overweight subjects to calorie restriction. It is widely recognized that diet modification and a reduction in overall caloric intake are the first line of treatment for obesity. However, this group explored how the presence of single nucleotide polymorphisms (SNP) in obesity related genes can influence a patient's response to calorie restriction. These polymorphisms can make it increasingly difficult for patients to lose weight despite a significant decrease in energy intake [8]. This notion is exceedingly relevant because of the global increase in the prevalence of obesity. It is one thing to identify a mutation or a change in a gene sequence, but it is entirely another to know exactly what these differences mean in terms of a biological response, such as effectiveness of a weight loss intervention. The vastness of the genome, proteome and metabolome is so great that it is difficult to gain and apply this information in a practical way.

It is also important to consider that technology of PM will not be limited to the boundaries of the clinic. In our rapidly advancing technological age, it is important to address the influence of mobile devices. Nutrition and weight loss websites, like myfitnesspal.com, often provide a mobile application that allows users to enter their food intake and generate a nutrient report. Imagine if such a report was able to give diet recommendations based on your genetic makeup. This would create the potential for a mobile application that could merge diet and genetic information for on demand and personalized recommendations. In a recent article, Arran Froot highlighted specific ways in which such a mobile application could

be used. The results discussed in the article showed that women who were considered "carbohydrate sensitive" (randomized to the low carbohydrate diet) and those considered "fat sensitive" (randomized to a low fat diet) lost two to three times more weight than women not randomized to their SNP [9]. Considering these results and the supersaturation of food choices in our society, a mobile application as previously discussed could have immense value in assisting people to make personally optimized dietary decisions.

The concept of personalizing medicine and diets is at a point of crystallization. New technologies will rapidly allow for further identification of gene sequences from patients and their disease states. The genetic discovery and treatment process will assuredly increase over the coming years. We are highly confident in regards to the future of PM, but even with recent breakthroughs there is a long way to go before genetic data collected in the clinic can be used to make medical or dietary recommendations to improve patient outcomes. When the full potential of PM is reached, the field of medicine and nutrition as we now know it will cease to exist. Those in the field of nutrition must work to incorporate genomics and personalization into our research and practices so that this study, so essential to human health, is not left on the sidelines.

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