Precision Nutrition in Maternal and Child Health:

AI-Powered Solutions

Dr. Sawsan Mohamed, Assistant Professor, College of Medicine - Qatar University

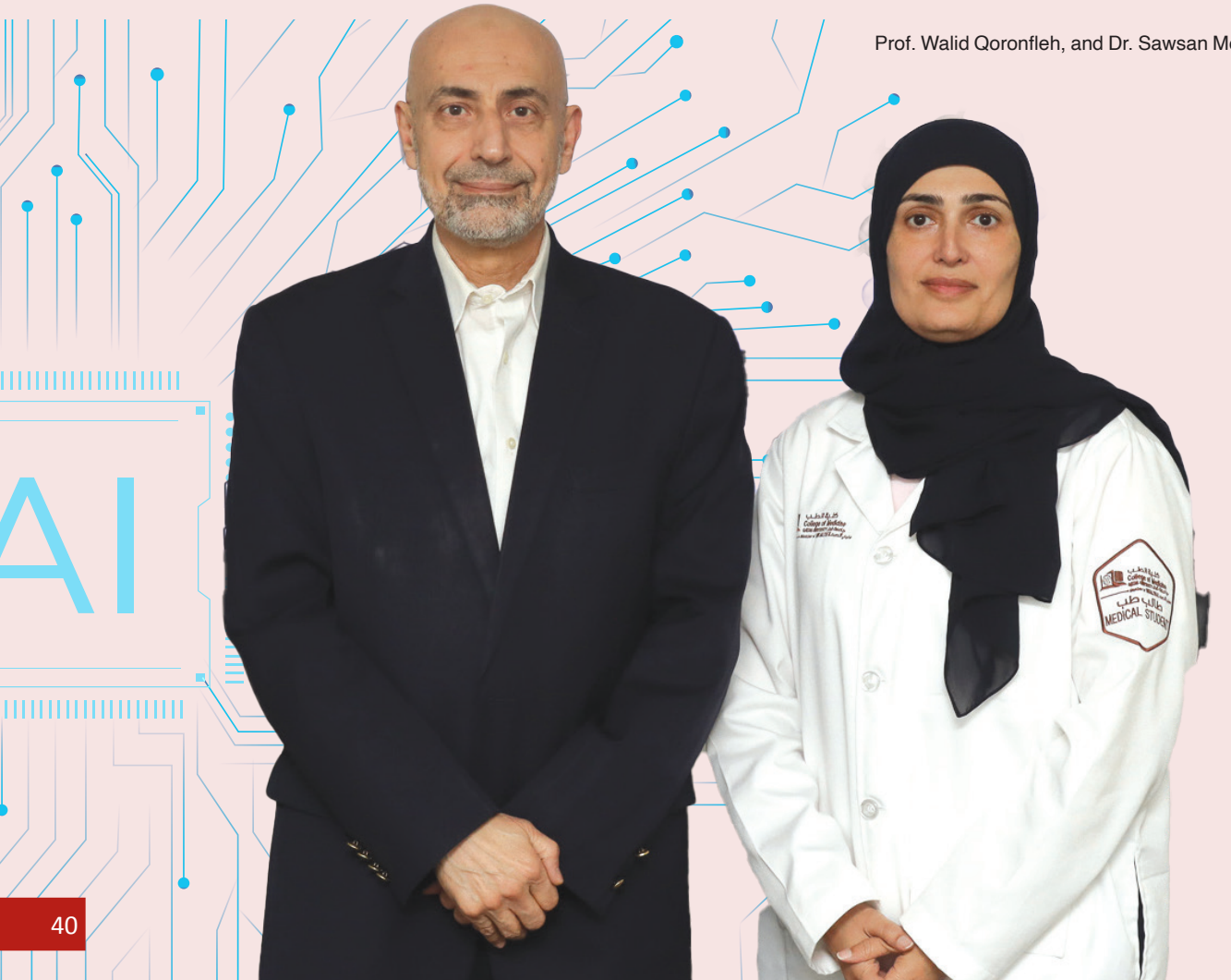
Prof. Walid Qoronfleh, PhD, MBA, Q3 Research Institute (QRI), Healthcare Research & Policy Division, Ann Arbor MI, USA

Precision nutrition (PN), also known as personalized nutrition, is an emerging field within lifestyle medicine. It delves into the interplay of genetic and non-genetic factors that influence disease risk and diagnosis. The focus of PN in lifestyle medicine is revolving around disease prevention through identifying genetic risk factors. Factors affecting nutritional health can be either non-modifiable or modifiable. Understanding these factors, whether they can be altered or not, is the center of developing a personalized nutrition plan that considers both non-modifiable and modifiable factors and their interactions. This approach aims to provide a comprehensive profile of patients' health risk, moving towards individualized nutrition care rather than a one-size-fits-all approach.

PN is built upon the foundations of nutrigenetics and nutrigenomics, which connect genetics with environmental factors like lifestyle and diet. These disciplines offer insights into how these factors influence gene expression. While nutrigenetics examine how genetic composition affects responses to nutrients and diets, nutrigenomics focuses on how nutrients impact gene expression. When combined, they provide a robust understanding of these interactions.

The advantages of PN are substantial, including potential reductions in healthcare costs, extended health and lifespan, and the ability to tailor nutrition plans to a patient's evolving health needs and personal circumstances. Additionally, PN can address personal interests beyond medical necessity, such as enhancing fertility, achieving fitness goals, and improving cognitive performance. Another area of interest is the contribution to developing nutraceuticals and functional foods, thus creating a new dimension of personalized medicine that incorporates genetic variability across different ethnic groups and individuals, thereby advancing precision medicine.

Our research focus is mainly on maternal and neonatal precision nutrition, specifically examining the vital roles of folic acid, thiamine, and vitamin B12. Previous research highlights the need for a comprehensive approach to nutrition for pregnant and lactating women. This approach should include assessments of individual and maternal



Prof. Walid Qoronfleh, and Dr. Sawsan Mohamed.

characteristics, genetics, and microbiota, due to the varying risks and treatment responses associated with different controllable and uncontrollable factors.

It is well-recognized that maternal nutrition significantly affects the risk of metabolic syndromes, nutrient deficiencies, and other health outcomes. PN can enhance prenatal care by promoting optimal health outcomes for both mother and child. Evaluating genetic predispositions and the intrauterine environment helps achieve the best possible outcomes throughout pregnancy and childbirth. Nutrient intake levels, including those of folic acid, thiamine, and vitamin B12, are essential from pre-conception to post-natal and childhood stages. Inadequate nutrition during these crucial periods can lead to developmental issues and increased risks of adverse health outcomes, some of which may be irreversible. Therefore, a PN approach tailored to pregnant women can help reduce the incidence of negative health outcomes through comprehensive assessments, including dietary, genetic, and anthropometric evaluations.

Artificial intelligence (AI) and machine learning (ML) are pivotal analytical tools in nutrition research. Unlike traditional nutritional intervention studies, which often focus on a limited number of nutrients and factors, AI can analyze extensive datasets that encompass a wide range of dietary and non-dietary variables. This capability allows for a more personalized and precise approach to developing nutritional interventions by accounting for each individual's unique factors. AI can also integrate multi-omics profiles to enhance the creation of tailored nutrition strategies. ML, a subset of AI, excels in considering numerous variables in diet patterns and combining them into a comprehensive assessment. This approach, known as "diet synergy," surpasses traditional nutritional assessments by enabling detailed analysis of interactions between diet, metabolism, genetics, personal characteristics, and microbiota.

One example of AI/ML application is the analysis conducted in the Nulliparous Pregnancy Outcomes Study: Monitoring Mothers-to-Be. Using the Super Learner, an ML algorithm combined with targeted maximum likelihood estimation (TMLE) methodology, researchers predicted adverse pregnancy outcomes—such as preterm birth, small-for-gestational-age birth, gestational diabetes, and pre-eclampsia—based on fruit and vegetable

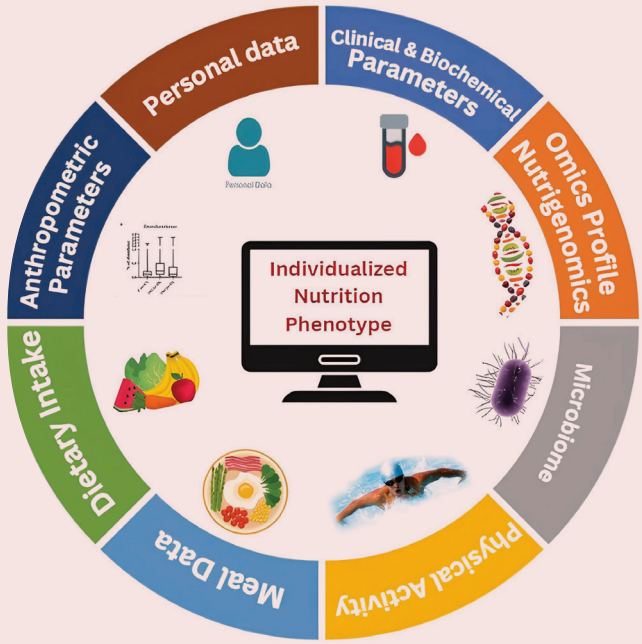


Figure 1: AI and Precision Nutrition. Multiple streams of data (big data) analysis via artificial intelligence and machine learning.

intake before and during early pregnancy. Another example is the use of ML to assess genetic risks for isolated orofacial clefts, also known as non-syndromic cleft lip with or without cleft palate (NSCL/P), a congenital condition influenced by both genetic and environmental factors.

In conclusion, given that the nutritional requirements for folic acid, thiamine, and vitamin B12 vary throughout an individual's life, precision nutrition (PN) can be a valuable tool for assessing these needs and understanding physiological responses to diet during critical phases such as fetal development, pregnancy, lactation, childhood, and adulthood. The need for these nutrients are not static and can change based on various 'omics' influences. The application of advanced technologies, particularly AI, in conjunction with multi-omics, represents a promising new direction in PN (Figure 1). Although there is substantial research on many aspects of nutrition, the integration of AI with multi-omics in PN remains underexplored. Therefore, further research is needed to fully understand and utilize these technologies in healthcare.

Future studies on PN focusing on maternal, fetal, and childhood health outcomes related to folic acid, thiamine, and vitamin B12 should target specific and relevant populations. This approach will help in integrating new findings into the PN model, potentially enhancing its effectiveness and application.