Investigating Metabolite-Diet Relationships to Diagnose Nutrient Deficiencies
Abhay Dharanikota
Medical Science Internship Program 2020
Virginia Commonwealth University School of Medicine

Abstract
Calcium deficiencies threaten bone health in adults and proper development in growing children; furthermore, they contribute to the risk of diseases including osteoporosis and hypertension. Recognizing dietary calcium deficiencies is important in addressing calcium shortages in toddlers and the elderly in Asia, however, studies have shown that current health monitoring methods for calcium intake are inefficient; personal monitoring methods are often incorrect, and professional methods are often sparse and unavailable to many. Problems with recall include mislabeling, inaccurate measurements, and ethnic diets; for example, in some cuisines, milk is watered down. Comparing dietary tests to individuals’ dietary recall showed that dietary patterns identified by the former were up to 38% more accurate. Through literature review, it is seen that urine tests which measure the health of an individual’s diet through metabolites can make calcium intake monitoring more efficient and available to the masses, therefore preventing calcium deficiencies. Metabolites in urine are the waste byproducts of foods that are "metabolized" by the body. Results from a US cohort reveal that a general test measuring multiple metabolites can accurately relay health patterns. The mapped metabolic activity of biochemical markers can give insights into nutrient intake such as calcium. With such testing made available to the masses, calcium deficiencies can be addressed with appropriate prevention and intervention strategies. Beyond testing for calcium deficiencies, metabolite testing can help diagnose and treat an array of diseases; for example, modified testing can help monitor diets of those affected by diabetes via glucose metabolite tracking. However, current impediments include economic concerns such as mass production and pricing, as well as further human trials.

Conclusions
Many biomarkers have been identified using metabolites; each are associated with the consumption of fruits, vegetables, and other foods. For example, proline and betaine were identified as biomarkers of citrus intake to monitor various physicochemicals. Applied mass spectrometry or NMR (nuclear magnetic resonance) in blood plasma and urine are used to extract metabolite profiles. These metabolite profiles are unique to each individual and can give insight into a person’s diet. Citric and formic acids have been found in higher concentrations in urine produced by diets high in calcium. Testing for these can reveal calcium deficiencies in diets.

Urinary spectroscopic characterization objectively captures the end-products of metabolism, therefore overcoming the problem of reporting bias in dietary records. The characterization is easily scalable as the H-NMR spectrum can measure hundreds of metabolites in a mere five minutes.

The individual metabolomic profiles produced by these tests findings suggest that these urinary metabolic profiles can be used as an objective measure to classify people’s dietary patterns. In tests, for each nutrient-metabolite association, the variable with the most significant correlation was recorded (the higher the peak, the higher the occurrence and vice versa as depicted in figure 2).

24-hour recall compared to 24-hour urine testing revealed that urine testing produced a more accurate phenotype of dietary intake testing over 60 nutrients.

Future Directions
Current impediments to making such testing available to the masses include economic concerns such as mass production and pricing. Spectrometry is required to analyse urine. Therefore, although a more efficient and personalized testing option, metabolite profiles still require a central testing location. In order to address this, further testing is required.

Beyond testing for calcium deficiencies, metabolite testing can help diagnose and treat an array of diseases; for example, modified testing can help monitor diets of those afflicted by diabetes via glucose metabolite tracking.

Current test results need to be modified so it is easier for patients to comprehend and monitor diet.

Acknowledgements
Thank you to the MSIP Directors Yuma Rahman, Martina Anophilenus, and Palina Bubka for their assistance.