Synthesis of a Symposium: Innovative Non- or Minimally-Invasive Technologies for Monitoring Health and Nutritional Status in Mothers and Young Children

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Considerable progress has been made in the ability to assess human nutritional status via new technologies. Many public and private laboratories in the United States are using methods that will greatly improve the medical community's ability to identify potential disease states earlier in their development and to assess appropriate personal interventions over the next decade and beyond. These methods come from a multitude of scientific disciplines positioning the added challenge of communication across disciplines. To the extent that communication across scientific disciplines can be focused on these new possibilities, this communication promises to speed development, maximize effectiveness of measurement strategies, gain complex acceptances and approvals and finally gain application in field environments.

The agenda for this symposium was the work of the Children's Nutrition Research Center of Baylor College of Medicine, the Centers for Disease Control and Prevention and staff from Agriculture Research Service and the Food and Nutrition Service (FNS) of the U.S. Department of Agriculture. Initial ideas for agenda items included a broad range of topics, such as breath tests for gastrointestinal function; dietary intake; urinary analytes; gene array chips for nutritional status correlation; scans for organ function and for muscle actions; hemoglobin, blood sugar, cardiovascular function via echocardiogram and ultrasound; serum triglyceride-rich lipoproteins via brachial artery ultrasound; body composition methods; physical maturity scales relating to bone density; physical activity measurement via accelerometers, biomarkers of food intake behavior; computerized methods for validation of food intake, fetal metabolism and anemia studies; essential fatty acid status, and buccal smears; hormonal status; micronutrient status such as iron, vitamin A, folate and iodine; and antibody measures for intake or exposure to proteins.

Clearly a large number of scientists could and should be involved in bringing focus to the potential use of these technologies and setting priorities for targeting them to the greatest health needs of the U.S. population and elsewhere. This symposium only touched the surface of the potential for information sharing, exchange of methodologies and testing and mutual support that is emerging across scientific disciplines.

Facilitation of this process will need to be greatly increased, with emphasis from areas of government that have resources to speed development, develop test environments and to broadly communicate observed health needs of particular groups. This facilitation is of particular interest to the Special Supplemental Nutrition Program for Women, Infants and Children (WIC).

WIC, administered by the U.S. Department of Agriculture via grants to state health departments, is a front-line defense in the nation's food security safety net. The WIC program is targeted to deliver nutritional benefits to those in the U.S. population who are most vulnerable to nutritional risk: low income pregnant, breastfeeding and postpartum women; infants; and preschool children (1). WIC provides nutritious foods, nutrition education, breastfeeding support and referrals to health and social service programs as an adjunct to good health care during the critical early years of growth and development. WIC currently provides service to over 7 million persons a year and at a federal cost of $4 billion.

Although many WIC participants are extremely poor, poverty alone is not sufficient in determining eligibility for WIC benefits. WIC eligibility determination includes both an income test to determine that an individual has family income at or below 185% of poverty and a determination of nutritional risk. WIC food benefits and other nutrition counseling are targeted to the individual's nutritional risk.

For WIC, nutritional risk is established based upon determination of at least one anthropometric, biochemical, clinical, dietary or significant predisposing condition (e.g., homelessness). The anthropometric testing has primarily been based on...
measures of height (or length) and weight, and the biochemical screening has primarily been blood tests for hemoglobin and/or hematocrit to identify anemia (2).

The most commonly recorded nutritional risks for participants served by WIC are:

- anemia for pregnant, breastfeeding and postpartum women as well as for children;
- high weight for height among pregnant, breastfeeding and postpartum women and children;
- inappropriate diet for all categories of women and children; and
- obstetrical risks for pregnant, breastfeeding and postpartum women in WIC (3).

During the decade of the 1990s, U.S. Department of Agriculture’s FNS has sponsored a series of steps to improve the WIC approach to nutritional risk determination. In 1993 FNS sponsored a project by the Institute of Medicine that resulted in the landmark 377-page publication “WIC Nutrition Risk Criteria: A Scientific Assessment” (4). This review created a scientific framework for assessing the appropriateness and usefulness of nutritional risk criteria, as they are needed for the WIC program. A review of scientific literature following this framework provided consensus in scientific support for most of the nutritional risk criteria in use by WIC state agencies. It also revealed the need for improvement of the scientific basis for risk determination in a number of areas (4). FNS worked cooperatively with the WIC community through the National Association of WIC Directors to interpret the findings of this report and in April of 1998 issued a policy to increase conformity of WIC nutritional risk criteria across the country. This policy became effective in 1999, and a process has been established for continuous improvement of the nutritional risk component of WIC through the FNS-National Association of WIC Directors Risk Identification and Selection Collaborative.

As WIC experienced substantial program growth throughout the 1990s and WIC clinics grew more crowded, local WIC staff described increasing stress levels in these clinics. Finger sticks to draw a blood sample for anemia screening are painful and often lead to crying and disruptions by young children at the WIC sites and doctors offices where the tests are performed. WIC expansion in these years also placed WIC service sites in a wide variety of environments beyond traditional public health settings. The cost of providing blood analyses for WIC participants still includes selecting WIC sites that are appropriate and/or hematocrit to identify anemia (2).

Ways to observe changes in true dietary intake to support disease prevention strategies that are timely and appropriate.
- Efficient on-site detection of iron and other deficiencies, and diet-related excesses.

The manuscripts that have been presented here offer considerable hope for improvement in these areas over the next decade through the use of new technologies. Some, such as orthogonal polarization spectral imaging as presented by Dr. Richard Nadeau, offer hope of minimally invasive measurement of hemoglobin in the relatively near future (6). Over a longer period, new types of observations allowed by this technology, such as vessel density, may lead to earlier and different insights regarding disease states. The use of the imagery depends on knowledge gained in other research that allows statistical correlations and standardized interpretations to be developed.

Optical technology and multivariate statistical techniques discussed by Dr. Gerard Cote have combined to open the field of absorption spectroscopy for assessment of iron, vitamin A, iodine and folate, which are key to health risks experienced by pregnant women, new mothers and their young children (7). Challenges remain in addressing overlapping spectra for various substances and variability of optical properties of body tissues within and between patients. Development of software to provide quantifiable and interpretable data is essential to continued progress in this field.

Saliva testing as described by Dr. Lindsay Hofman shows promise for assessing real as opposed to reported smoking behaviors or in predicting preterm delivery for pregnant women (8). Blood spots dried on filter paper as reported by Dr. Joanne Mei (9) and Dr. Neal Craft (10) can be used for infant screening for metabolic and heritable disorders and for assessment of vitamin A status. Dr. Kenneth Ellis (11) considered new technologies for assessing body composition, such as air displacement plethysmograph, three-dimensional photon scanning and bioelectrical impedance spectroscopy, with established reference methods.

Dr. Dietrich Matern has shown ways that mass spectrometry offers opportunity for high volume testing of single or related groups of metabolites using a growing variety of media (12). However, lack of easy maintenance of equipment and labor-intensive nonstandardized methods for interpretation are key barriers to widespread use. Other approaches such as breath testing discussed by Dr. Peter Klein seem more distant in their widespread application due to the narrow range of conditions that they address (13).

Deoxyribonucleic acid microarray technologies as presented by Drs. Karen and Kendal Hirsch suggest new paths for observing patterns that can assist in modeling human regulatory mechanisms and networks as well as mapping disease progression (14). The understanding of nutrition, as well as many other fields, is expected to be fundamentally changed as it becomes possible to address cellular level actions of specific nutrients. In time, this will allow selection of the most effective interventions for individual patients.

As WIC continues to address the nutrition needs of those at greatest risk in our population, these technologies will open new doors for coordination with other stakeholders in this growing ability toward health assessment. The Food and Nutrition Service and the Agriculture Research Service extend appreciation to these authors and to the many researchers who are working to improve the ability to assess nutritional status and to create appropriate interventions for those at nutritional risk.
LITERATURE CITED


