Perspectives on Data Quality - Panel Discussion
"Observations from a Clinical Research Center"

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As a nutritionist in a small research unit (1) I find that food composition data is not well understood by investigators in other fields. I think we, as nutritionists and dietitians, are responsible for this situation because we often quote nutrient data in absolute terms. In our zeal to make nutrition understandable we sometimes over-simplify food composition. Our clients may not understand that when we say bread has 70 Calories per slice, an apple has 80 Calories, or a Cookie 120 Calories that we are talking about averages. They usually have no concept of how much variability may occur in food composition data.

My investigators understand the composition of other biological compounds. They know that the normal value for hemoglobin is 14 mg% with a range of 12 to 16 and that men generally have higher values than women. No one expects hemoglobin to be exactly 14 mg%. It is routinely measured because it can vary from 6 to 26 mg%. But our food tables and simplified educational messages have led our audiences to

expect simple answers. As a result, most investigators would not expect an apple to vary from 50 to 100 Calories. Most people have never seen a range of normal values for nutrient composition data, rather they expect a food table to resemble the absoluteness of Boyle's gas laws.

So how does this affect my work? I operate the nutrition service in a small NIH research center in Iowa. In my unit we devise diets with known composition for a variety of studies. We do this by designing diets using food composition data primarily from USDA Handbook 8, Composition of Food, Raw, Processed, Prepared (2). Our studies always control for carbohydrate, protein, fat, and the major fatty acid classes; usually they are controlled for sodium, potassium, calcium, and phosphorus content, and sometimes for nutrients as diverse as biotin or carnitine. Diets are planned by calculating the nutrient composition of menus. The decision to analyze diets to verify calculations is made individually for each study and generally food analyses are conducted sparingly. Murphy, Watt, and Rizek warned researchers of the limitations of food tables for metabolic research in 1973 when they wrote:

"... a potential and serious misuse of the tables deserves some comment. In a few instances, inquiries from researchers have indicated that they would like to calculate nutrients in diets used in metabolic studies. The temptation to cut costs and save time by taking this kind of shortcut is enormous. However, in metabolic research where great precision is required, only analysis of an aliquot of the particular foodstuffs being consumed will have sufficient accuracy for balancing intake of nutrient against utilization by an individual at a specific time." (3)

Inspite of the known variability in food composition and warnings from developers of the data, we in the field find using USDA food composition data to calculate research diets to be effective and efficient. Deciding when calculations will suffice and when analysis is required involves a cost/benefit analysis. Some studies do not require the accuracy of analysis. Analysis of multiple nutrients is expensive. We are fortunate at Iowa to have a nutrition laboratory set up to conduct assays on food for a variety of nutrients. They are not set up at our convenience, rather our samples are analyzed at their convenience -- a relationship I nurture, because without their service we could conduct fewer analyses and the cost would be higher.

An obvious question when determining cost vs. benefit of diet analyses is "How well do calculations of diets reflect actual analyses?" To answer this question I reviewed results of analyses of diets we have prepared over the last ten years. Sometimes analyses closely agree with calculations and sometimes they do not. Below are examples that illustrate our experience with diet calculations and subsequent food analyses.

Figure 1 shows a series of nitrogen analyses from 12 different menus for 12 subjects who consumed their same daily menu for 10 days. Each circle represents the 11th diet which was prepared along with the previous 10 and reserved for analysis. This additional diet is sometimes referred to as a "second" tray since it duplicates the "first" tray which is consumed. The solid line on the graph represents our calculated value and the dotted lines are + 10%. In these studies the results of the analyses are not known until several days or weeks after the study is completed. You might contrast the variability we experience in our data to the variability allowed in a current multicentered study who require the 95% confidence interval to be + 1.5% as opposed to our variability which might exceed 10%. If we set the confidence interval this tight we would lose over half of our diets which was exactly the experience of the Delta study (4). As they prepared their meals; at least half of the menus they developed had to be reformulated to meet the tight criteria (5).

In a second study, potassium control was needed so on two occasions we prepared a second tray for analyses for each of 11 subjects. We used one basic menu with food amounts increased or decreased to

hold potassium content constant while adjusting Calories to meet the subject's requirement. Figure 2 shows the duplicate analyses ordered from left to right to show decreasing agreement between analyses of the duplicate trays. A few diets analyzed exactly like their matching tray, but some varied as much as 10% from their corresponding diet which may reflect a combination of preparation and analytical variation. However, most of the diets provided less than the calculated amount, with the mean value for the first diet analysis being 94% and the second diet 95% of the calculated amount.

Sometimes we encounter diets difficult to achieve with food. Our diets that provided 10 and 400 mEq sodium are an example of this problem. We rarely analyze individual foods, but when we found that one of our two high sodium menus provided 40 mEq less sodium than the other we analyzed some of our high sodium products. In doing so we discovered that the two broth products we used had different sodium contents (Figure 3). Diets which included beef broth had vastly different sodium values than similar diets which included chicken broth, reflecting differences in the two broths. Here we might ask, is the food table "wrong" because it does not show the same sodium content as the broth, or is the broth "wrong" because it does not provide the same amount of sodium as the table?

In general, analyses we have conducted over the past 10 years have shown that calculations effectively predict the composition of mixed diets, but they do not fully explain the variability we sometimes observe. As we have tried to reconcile differences between calculations and analyses, the most obvious sources of variation are variability in the preparation of the diet or analytical variability in the laboratory. We must continually monitor our preparation methods to eliminate variability in the kitchen. But I need more experience in monitoring analyses conducted outside our kitchen.

One valuable outcome of the National Nutrient Databank for me is learning how to evaluate analytical data. I would like to see more guidance on how to monitor my own analytical data. What questions should I ask the laboratory about their quality control? What should I ask the laboratory about their methodology? What I really want from the USDA is a "cook book" of analytical procedures for the foods laboratory. Dietitians and nutritionists have many opportunities to be familiar with variation in food quality and preparation methods, but relatively little opportunity to understand variation in analytical methodology. A manual providing guidance to the practitioner who must contract for food analyses would enable researchers to use food tables more effectively.

References:

1. General Clinical Research Center, University of Iowa, Iowa City, IA, 52242.
2. USDA, HNIS, Handbook 8, Composition of Food, Raw, Processed, Prepared. Sections 1 - 21, Washington, DC: Government Printing Office, 1976 to 1992.
3. Murphy EW, BK Watt, and RL Rizek. Tables of food composition: availability, uses, and limitations. Food Tech 27:40-51, 1973.
4. Dietary Effects on Lipoproteins and Thrombogenic Activity, DELTA, NIH, NHLBI, 7550 Wisconsin Ave, Federal Building, Room 604, Bethesda, MD 20892.
5. Personal Communication, Kent Stewart, PhD, Virginia Polytechnic Institute and State University, Blacksburg, Virginia, May, 1994.

Figure 1. Calculated versus analyzed protein content of different low protein diets (1991-1993)

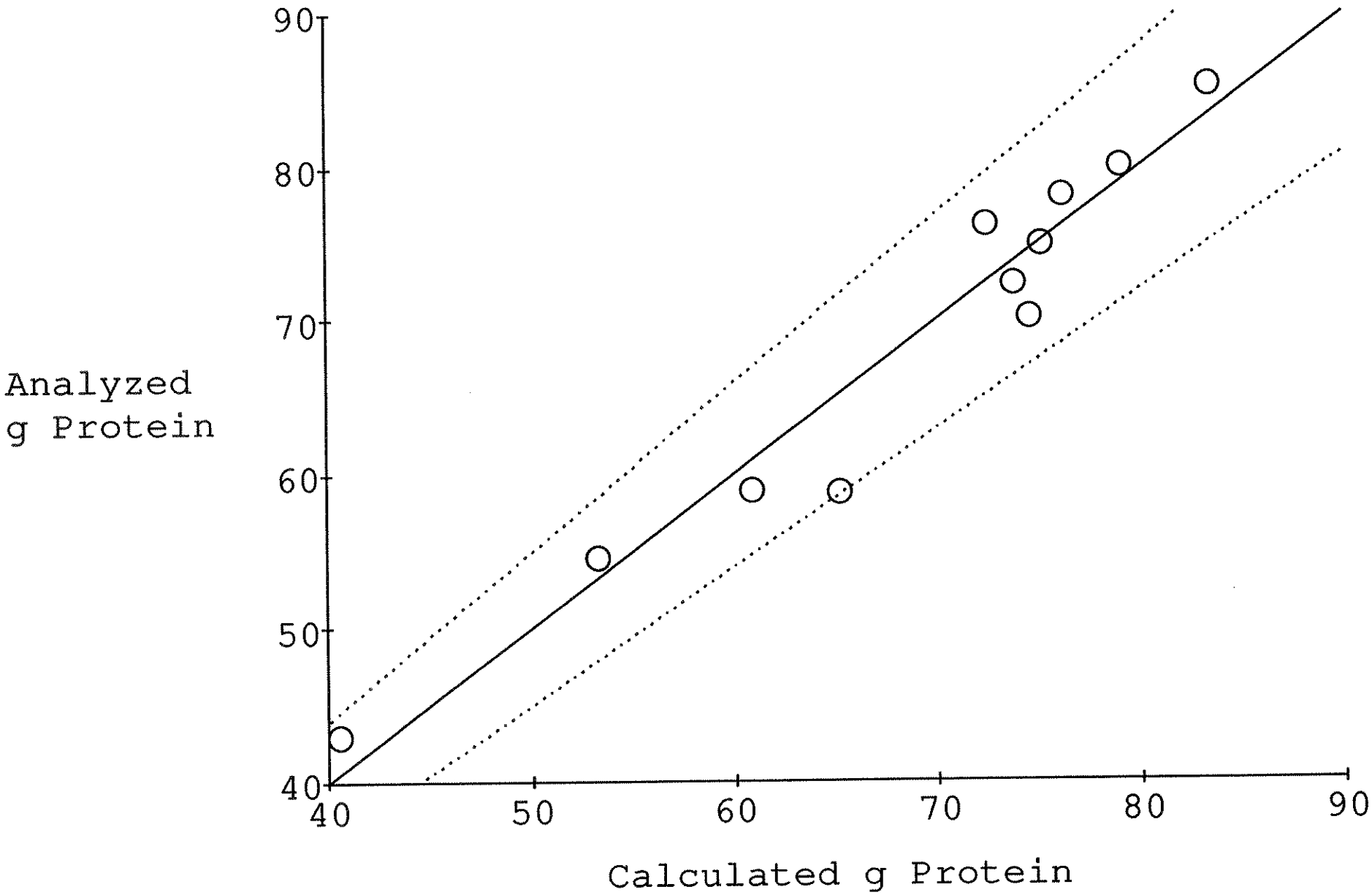

Figure 2. Percent differences between potassium analyses of duplicate 102 mEq potassium diets (1989)

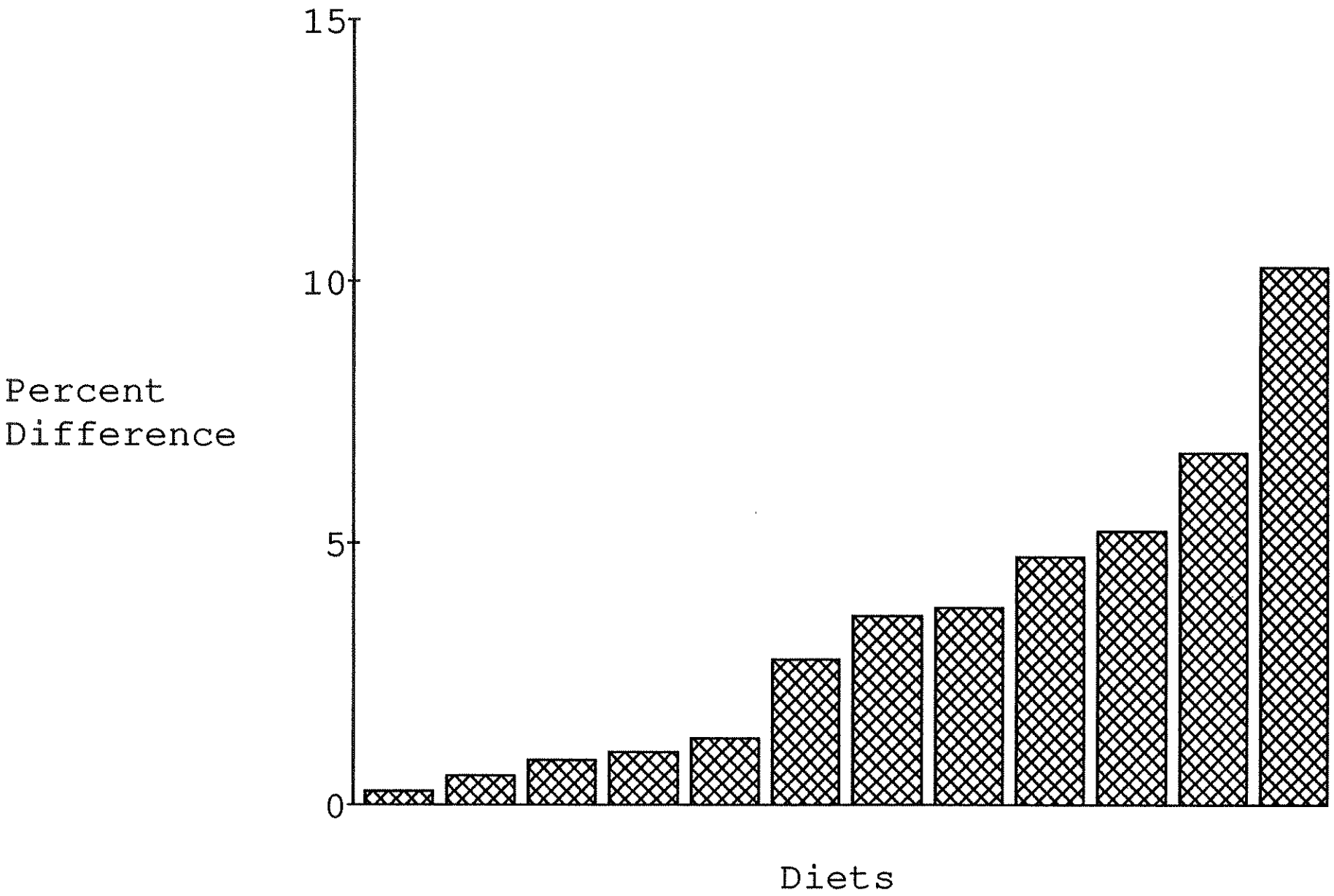

Figure 3. Calculated and analyzed sodium content of 100 grams soup base (U of Iowa, 1986)