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Cross-Border Use of Food Databases: Equivalence of US and Australian Databases for Macronutrients

Suzanne S. Summer, MS, RD [clinical research manager],
Clinical Translational Research Center

Nicholas J. Ollberding, PhD [assistant professor of pediatrics],
Division of Biostatistics and Epidemiology

Trish Guy, APD* [corporate nutrition manager],
Australia Sanitarium Health & Wellbeing Company, Berkeley Vale, New South Wales, Australia.

Kenneth D. R. Setchell, PhD [professor],
Department of Pathology and Laboratory Medicine

Nadine Brown, PhD [research associate], and
Department of Pathology and Laboratory Medicine

Heidi J. Kalkwarf, PhD, RD [professor]
Division of General and Community Pediatrics, all at the Cincinnati Children's Hospital Medical Center, Cincinnati, OH

Abstract

When estimating dietary intake across multiple countries, the lack of a single comprehensive dietary database may lead researchers to modify one database to analyze intakes for all participants. This approach may yield results different from those using the country-specific database and introduce measurement error. We examined whether nutrient intakes of Australians calculated with a modified US database would be similar to those calculated with an Australian database. We analyzed 3-day food records of 68 Australian adults using the US-based Nutrition Data System for Research, modified to reflect food items consumed in Australia. Modification entailed identifying a substitute food whose energy and macronutrient content were within 10% of the Australian food or by adding a new food to the database. Paired Wilcoxon signed rank tests were used to compare differences in nutrient intakes estimated by both databases, and Pearson and intraclass correlation coefficients measured degree of association and agreement between intake estimates for individuals. Median intakes of energy, carbohydrate, protein, and fiber differed by <5% at the group level. Larger discrepancies were seen for fat (11%; $P < 0.0001$) and most micronutrients. Despite strong correlations, nutrient intakes differed by >10% for an appreciable percentage of participants (35% for energy to 69% for total fat). Adding country-specific food items to an existing database resulted in similar overall macronutrient intake estimates but was insufficient for estimating individual intakes. When analyzing nutrient intakes in multinational studies, greater standardization and modification of databases may be required to more accurately estimate intake of individuals.

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Address correspondence to: Suzanne S. Summer, MS, RD, Clinical Translational Research Center, Cincinnati Children's Hospital Medical Center, 3333 Burnet Ave, Cincinnati, OH 45229. Suzanne.summer@cchmc.org.

*Accredited Practising Dietitian (Australia).

STATEMENT OF POTENTIAL CONFLICT OF INTEREST K. D. R. Setchell is a consultant to and T. Guy is an employee of the Sanitarium Health & Wellbeing Company, New South Wales, Australia. No potential conflict of interest was reported by the other authors.

Keywords

Food composition; Nutrient database; International; Harmonization

MEASURING DIETARY INTAKE OF INDIVIDUALS residing in different countries poses the challenge of determining how to analyze the nutrient content of foods consumed. Ideally, a single standardized dietary database could be used to estimate food and nutrient consumption across countries. The International Network of Food Data Systems (INFOODS), created by the United Nations in 1983,^{1,2} is composed of regional data centers that develop food and nutrient databases for analyzing intake among neighboring countries.^{1,3,4} A comprehensive, global database or appropriate regional database that could be used to study intake among non-neighboring countries such as the United States and Australia have yet to be developed. In the absence of such databases, dietetics practitioners and researchers often modify one country's database to make it better suited to determine food and nutrient intake in other countries. In practice, this includes incorporating foods unique to each population. These database modifications, however, may not be sufficient to accurately reflect actual nutrient intakes. Inaccurate estimation of actual intake is an important source of measurement error. Error in measuring true nutrient intake may lead to bias and distortion when estimating population-level intake distributions and diet–disease associations.⁴ Studies attempting to modify one country's database to analyze dietary intakes in another have yielded conflicting results^{5–7} and differences may reflect, in part, the extent of modification to the dietary database.

As part of a multinational study conducted in the United States and Australia, we examined whether amending an existing US database to reflect food items consumed in Australia could accurately measure nutrient intake in an Australian cohort. The focus of the parent study was on macronutrients, so modifications to the US database were performed for food items that differed by >10% for energy, macronutrients, or fiber. The selection of foods and the cut-point for amending the database were chosen to reflect modifications that may occur in practice when more comprehensive standardization is not feasible. To our knowledge, no published studies have reported on database agreement for these two countries.

METHODS

Dietary intake data were collected from adults participating in a study examining the effects of macronutrient and fiber intake on the body's production of equol, a soy isoflavone metabolite believed to enhance the health benefits of consuming soy products. This multisite study was conducted at Cincinnati Children's Hospital Medical Center (CCHMC) in the United States and Sanitarium Health & Wellbeing Company (SHW) in Australia. This report focuses on data from the Australian participants only. Australian participants were recruited by SHW in conjunction with Sydney Adventist Hospital. Data collection took place during 2006 and 2007 at the Head Office in Berkeley Vale, New South Wales, Australia, and at the Food Research Laboratories in Cooranbong, New South Wales, Australia. The study was approved by the CCHMC Institutional Review Board and conducted according to the ethical standards of Sydney Adventist Hospital and the Australian Human Research Ethics Committee guidelines. Written informed consent was obtained from all participants before enrollment.

Assessment of Dietary Intake

Participants recorded their food and beverage intake for three consecutive days (2 weekdays, 1 weekend day). Participants were instructed on how to record intake, including estimation of portion size and preparation methods, by an accredited practising dietitian (APD), the

Australian equivalent of a US registered dietitian (RD). Recording booklets given to participants included written instructions and examples of how to record food details and amounts. Completed diet records were reviewed and clarified with participants by the APD before analysis.

Nutrient Intake Analysis

Diet records were coded (entered into a nutrient analysis program) in Australia by SHW nutrition staff (an APD and a trained technician), and in the United States by nutrition research staff (an RD and two research assistants) at CCHMC. Dietary data from the food records of Australians were analyzed using Australian Food and Nutrient Database 1999, a food composition database created by Food Standards Australia New Zealand. The same records were analyzed in the United States using Nutrition Data System for Research (NDSR), software versions 2005, 2006, and 2007 (Nutrition Coordinating Center, University of Minnesota). Multiple versions were used to reflect the marketplace throughout the multiyear study. The NDSR time-related database updates analytic data while maintaining nutrient profiles true to the version used for data coding.⁸ Final calculations were completed using NDSR 2011.

The following steps were taken to limit data entry error and ensure that dietary data were coded similarly in both countries. First, the APD and RD reviewed all food records before coding, clarifying details and unfamiliar foods. The APD and RD developed a standardized approach for coding food records at both sites. Study-specific data-entry rules were established. The number of coders per site was limited, and each was trained in food data entry and use of their respective database programs. Completed entries were randomly checked by a second coder for quality assurance. When participants prepared a home recipe, they recorded ingredients, amounts, and serving size. The entire recipe was entered into the database, along with the portion consumed. Because many foods available in both countries have different common names, the APD and RD created a food reference list that contained Australian and US names for the same food. For example, in Australia cookies are “biscuits” and cantaloupe is “rockmelon.”

Some packaged foods consumed in Australia were not listed in the US database, making it necessary to modify the database. We identified a substitute food in NDSR that was in the same general food category (eg, snack chips or desserts), and whose macronutrient content was within 10% of that given in the Australian database. This range was selected based on data showing that calculated values of energy and macronutrient intakes fall within 5% to 10% of the values determined by chemical analysis of a food composite containing the exact same foods and amounts.⁹ Food items that met these criteria were entered into the database in place of the missing food. When more than one acceptable food was identified, we selected the one closest in kilocalories per serving. When an acceptable substitute could not be identified, that food item was added to the database. The nutrient content was determined using the most similar US substitute food identified in NDSR based on energy, macronutrients, and fiber, and the macronutrients were then modified to match those of the Australian product. No modifications were made to micronutrients. All natural, unprocessed foods (fresh fruits, vegetables, grains, and meats) were left unmodified.

Statistical Methods

Estimated nutrient intakes obtained from the US and Australian databases were calculated by averaging the 3-day food records and presented as total intakes per day. The absolute and percent differences in estimates of nutrient intake between databases were compared using a paired Wilcoxon signed rank test. These comparisons inform the equality of estimates for group comparisons. A nonparametric test was used as the distribution of differences for

several nutrients deviated from normality. Percent differences between nutrient intake estimates facilitate understanding of the magnitude of the difference for each nutrient given the large range in food and energy intake among individuals. Pearson and intra-class correlation coefficients were used, respectively, to assess correlation of and agreement in nutrient intake estimates between databases for individuals. Values were log-transformed for these analyses. Bland-Altman plots were used to display the agreement (ie, percent differences in estimates of nutrient intake) between databases as a function of total intake of each nutrient. The limits of agreement were set at $\pm 10\%$, consistent with our a priori threshold of 10% for database modifications. Spearman correlation coefficients between these measures were calculated to assess whether there was a differential bias in nutrient intake estimates. All tests were two-sided with $P < 0.05$ considered statistically significant. Data analyses were performed using JMP version 8 (2009, SAS Institute Inc) and SAS version 9.3 statistical software (2011, SAS Institute Inc).

RESULTS AND DISCUSSION

Dietary intake data from 68 Australian adults were included in the analysis. Participants were men and women (49% women) ranging in age from 18 to 65 years (mean age 37 years), were primarily white (97%), and reported a mean body mass index of 24.3. Of all foods recorded in the 3-day food records, we found 81 packaged foods consumed in Australia that were not contained in the US database. Of these, a substitute food item differing by $< 10\%$ for energy, macronutrients, and fiber was identified for just five foods. The remaining 76 Australian food items were added to the database. These were packaged brand foods popular in Australia such as Up & Go (Sanitarium Health & Wellbeing) supplement beverage, Tim Tam chocolate biscuits (Arnott's), Light 'n' Tasty breakfast cereal (Sanitarium Health & Well-being), and Milo (Nestlé) powdered drink mix. These items were recorded 221 times, reflecting 4.4% of the 4,985 total recorded foods. A majority of participants (80%) consumed at least one of these modified packaged food items.

Results of group level comparisons of nutrient intakes estimated using the Australian and modified US database are given in the Table. Differences in intake estimates for energy, protein, carbohydrates, and fiber were small ($\leq 5\%$) and within our acceptable level of error (10%), despite nominal statistical significance. The difference between databases for fat intake was greater (11%; $P < 0.0001$). Although micronutrients were not a focus of the parent study and were not modified in the US database, data on micronutrients are presented for comparison. There were large differences in median intakes of several micronutrients including folate (55%; $P < 0.0001$), vitamin A (32%; $P < 0.0001$), and iron (29%; $P < 0.0001$). Interestingly, estimates for potassium were not found to differ between databases (1%; $P = 0.64$) suggesting database values may be more consistent for this measure. In line with our findings, Hakala and colleagues⁵ reported that mean macronutrient intake of 20 men in Sweden was similar when analyzed using either a Swedish or Finnish nutrient database. In that study, substitutions for Finnish food items were made and calculation methods, such as energy conversion factors, were standardized across databases. These findings suggest that estimates of macronutrient intake may be similar at the group level with only minor modifications to an existing database. However, differences are likely to be greater for less comparable populations, and the agreement for specific macronutrients (eg, fat) may differ across databases. In contrast to our findings for micronutrients, Csizmadia and colleagues⁶ extensively modified a US database for use in a Canadian population and reported mean intakes within $\pm 5\%$ for all micronutrients examined, except folate, vitamin A, and iron. Discrepancies for micronutrients were more pronounced in our study and would lead to greater distortion when estimating population-level measures. Thus, dietetics practitioners and researchers should consider more comprehensive standardization with a focus on micronutrients when greater accuracy is required.

For energy, macronutrients, and fiber, Pearson correlations ranged from 0.92 ($P<0.001$) for carbohydrates to 0.83 ($P<0.001$) for fat. Intraclass correlations were lower reflecting differences in absolute agreement at the individual level. Despite high values for the correlations, macronutrient intakes differed by $>10\%$ for an appreciable percentage of participants, ranging from 35% for energy to 69% for fat. For example, discrepancies between databases for fat ranged from an underestimate of 43% to an overestimate of 57%. Examination of Bland-Altman plots highlights the limited accuracy of the modified US database to assess dietary intake at the individual level when compared with the Australian database (see the Figure). For several nutrients, the percent difference was correlated with mean intake indicating that the discrepancies between databases increased as a function of total intake more so than what would be expected assuming proportional error. For micronutrients, the correlation and agreement between databases was generally much lower, and there was extensive misclassification of individuals by $>10\%$ for micronutrient intakes, ranging from 41% for potassium to 96% for folate. Similar discordance between a US and Canadian database for estimating individual micronutrient intakes was reported in a previous study.⁶ Therefore, dietetics practitioners and researchers must consider that large discrepancies in nutrient intake may occur at the individual level when attempting to modify a dietary database for use in another country. The degree to which database modification does not fully account for differences in actual dietary intake will allow for misclassification error that may appreciably affect risk estimates in diet–disease studies.

Currently, nutrition research involving individuals residing in multiple countries is limited by the lack of standardization in dietary databases across sites. For our analysis, we compared NDSR with the Australian Food and Nutrient Database because it is the most comprehensive database of Australian foods. However, neither database can be considered a true gold standard for our population. The Australian Food and Nutrient Database is limited with respect to the number of food items, percentage of imputed values, and frequency of updating, and NDSR does not reflect local culture, fortification, agricultural practices, or foods. We chose to modify the more comprehensive of the databases, which seemed a practical choice when conducting a study comprising Australian and US participants. Presumably this database could then be used to estimate nutrient intakes for both groups. However, differences between databases were $>10\%$ for group level fat intake and for the majority of individuals for several nutrients. These findings are likely driven by differences between databases in nutrient values for foods already included in both databases. An alternate approach would have been to calculate dietary intakes separately for each country using a country-specific nutrient database, and then combine results for analysis. However, this approach will also result in bias at the group and individual levels to the extent that the databases differ. In the absence of suitable biomarkers for a wide range of nutrients, it remains to be determined whether the benefits achieved by database standardization outweigh the potential errors that incomplete standardization may introduce. Future studies assessing the extent to which differences in approach and extent of standardization result in greater agreement between databases will advance our understanding.

There are limitations to this study. Despite the procedures in place to minimize inconsistencies in coding dietary data across sites, errors may have occurred. Standardization of diet data coding across multiple sites is crucial to achieving accurate results.¹⁰ Also, we did not consider ranges other than $\pm 10\%$ for energy or macronutrient differences before a food was modified and were, therefore, unable to examine the influence of different approaches on database agreement. A more stringent cut-point may have improved nutrient estimates. In addition, only packaged food items were modified. Although this was a deliberate attempt to reflect modifications that may occur in practice, more extensive standardization of the databases is expected to improve agreement. Also, all

participants were enrolled in a nutrition intervention study potentially limiting the generalizability of findings to all Australian adults.

CONCLUSIONS

We found that modifying an existing US database to account for foods unique to Australia resulted in similar estimates for energy, protein, carbohydrates, and fiber at the group level. However, agreement was poor at the individual level for all measures examined and was likely to affect estimates of diet–disease associations. More extensive database modification would be necessary to achieve greater accuracy. Careful consideration should be given when attempting to employ one country's food database to analyze intake in another country. Greater standardization across country-specific databases may reduce measurement error.

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Figure.

Percentage difference (Australia minus United States) in nutrient intake estimates in relation to the mean (Australia and United States) nutrient intake. Shaded areas represent values falling within $\pm 10\%$ of mean intake.

Table
Comparison of Australian and US databases in estimating nutrient intake of Australian adults (N=68)

Nutrient	Australian Database	US Database	Difference Australia-US Databases	P value ^a	% Difference Australia-US databases	% Subjects within $\pm 10\%$ ^b	Pearson correlation coefficient ^c	Intraclass correlation coefficient ^c
	$\leftarrow \text{median (min-max)} \rightarrow$				$\leftarrow \text{median (min-max)} \rightarrow$			
Energy (kcal)	2,199 (1,300 to 4,472)	2,158 (1,216 to 3,759)	58 (-657 to 836)	0.04	3 (-39 to 34)	65	0.89	0.89
Protein (g)	89 (48 to 135)	83 (45 to 133)	4 (-27 to 29)	0.02	5 (-23 to 29)	56	0.89	0.87
Carbohydrate (g)	284 (153 to 698)	299 (162 to 563)	-4 (-97 to 141)	0.28	-2 (-40 to 38)	62	0.92	0.91
Fat (g)	83 (33 to 169)	76 (33 to 151)	9 (-34 to 43)	<0.0001	11 (-43 to 57)	31	0.83	0.79
Fiber (g)	29 (13 to 61)	30 (11 to 61)	1 (-13 to 16)	0.03	3 (-40 to 60)	50	0.90	0.89
Beta carotene (μg)	4,460 (573 to 20,329)	5,831 (399 to 26,270)	-1,493 (-20,925 to 12,031)	<0.0001	-26 (-139 to 84)	21	0.79	0.72
Retinol (μg)	392 (90 to 1,163)	512 (204 to 1,900)	-135 (-1,474 to 296)	<0.0001	-30 (-143 to 60)	18	0.44	0.25
Vitamin A (mg)	1,286 (394 to 3,838)	1,635 (321 to 4,798)	-480 (-3,681 to 1,858)	<0.0001	-32 (-124 to 64)	10	0.68	0.54
Folate (μg)	387 (172 to 815)	573 (267 to 1,505)	-260 (-1,722 to 144)	<0.0001	-55 (-137 to 32)	4	0.75	0.28
Vitamin C (mg)	128 (38 to 638)	124 (30 to 524)	25 (-879 to 402)	0.006	20 (-148 to 106)	16	0.81	0.77
Calcium (mg)	964 (392 to 1,790)	1,024 (511 to 2,094)	-81 (-631 to 607)	0.0009	-7 (-45 to 43)	46	0.88	0.87
Iron (mg)	15 (6 to 30)	19 (10 to 45)	-4 (-36 to 7)	<0.0001	-29 (-104 to 28)	16	0.77	0.53
Potassium (mg)	3,501 (2,102 to 6,565)	3,496 (1,617 to 6,416)	18 (-1,036 to 1,541)	0.64	1 (-33 to 47)	59	0.86	0.86

^aFor Wilcoxon signed rank test.

^bPercent of participants for which the difference between the Australian and US databases was $<10\%$.

^cCalculated using the natural log-transformed values.