Data collected as part of Pathways, a school-based trial for the primary prevention of obesity in American Indian children conducted between 1997 and 2000, were analyzed to examine possible intervention-related bias in food reporting. The authors hypothesized that children in the intervention schools may have systematically underreported their dietary intake relative to children in the control schools. Nutrient intake estimates for lunch derived from record-assisted 24-hour dietary recalls were compared with intake estimates from observed lunch intakes. Reported nutrient intakes were included in regression analyses as the dependent variables; observed intake, intervention condition, and age were included as independent variables. Results indicated that, among females, intervention condition was a significant predictor of reported energy, fat, and saturated fatty acid intakes. Independently of observed intake, reported lunch energy intake among females in the intervention schools was 66.8 calories lower than reported intake among females in the control schools (p = 0.03). These findings suggest that investigators should consider bias in reporting of dietary intake by intervention condition when conducting diet-focused intervention studies. Specifically, enhancing measures that rely on self-reports with objective measures of dietary intake would help investigators to evaluate whether differential reporting by treatment group has occurred.
Subjects

The design and content of the Pathways intervention have been described in detail elsewhere (7, 8). In brief, 41 elementary schools in seven American Indian communities were randomized to intervention and control conditions. The intervention included a classroom curriculum, physical education, school food service, and family components. The nutritional aspects of the curriculum and the family component emphasized making lower-fat food choices and learning healthy eating behaviors. The food-service intervention included nutrient and behavioral guidelines targeted toward reducing the amount of fat in school meals. The intervention began in the fall of the third grade (1997) and continued through the fifth grade (2000).

The institutional review boards at each participating university and tribe approved the study protocol, as well as the manner in which parental informed consent and children’s assent were obtained.

Measurements

Children were enrolled in the study and baseline measurements were completed at the end of the second grade, with selected measurements being conducted each spring through the fifth grade (follow-up). The impact of the Pathways intervention on diet was assessed in two ways: direct observation of children eating school lunches and record-assisted 24-hour dietary recalls. School lunch observation was chosen because it provides an objective estimate of intake unbiased by self-reporting (9, 10). Record-assisted 24-hour dietary recalls were used because they provide assessments of dietary intake for the entire day (11).

School lunch observation was conducted each spring on a sample of approximately 15 children in each school. At baseline, the children for the lunch observations were randomly chosen within each school. In subsequent years, as many of the same children were observed as possible, with additional children being chosen at random when the cohort children were not available. Lunch observations were made on at least two separate days in each school.

The approach of Gittelsohn et al. (9) served as the model for lunch observations. Observers evaluated each child’s initial serving relative to a standard tray with expected foods and serving sizes. Each data collector observed up to three children at a time as inconspicuously as possible, recording portion sizes, food choices, food brought from home, food trading, food spillage, and second servings. Following lunch, amounts of food remaining on the children’s plates were measured using standardized utensils and recorded, thus allowing for calculation of food consumed. Data collectors were centrally trained and certified by two of the authors. To ensure a high skill level, observers were trained until they could visually estimate portions with less than 20 percent error, and they were graded against observations of the same children by expert observers.

Record-assisted 24-hour dietary recalls were administered during the spring of the fifth grade. The decision to use this posttest-only design for the recalls was based on anticipated difficulties in obtaining valid recalls from second-grade children at baseline (12, 13) and because of additional expense. Record-assisted dietary recalls were collected from random samples of approximately 15 children per school.

The recalls were collected on the day following the observation of the child’s eating; hence, the recall information included observed lunch intake. Prior to the 24-hour recall period, children were trained to complete an abbreviated food record for use as a memory prompt during their recall interviews the next day.

Recalls were conducted in person using the Nutrition Data System for Research (version 4.02_30), a computer-based software application that allows for direct entry of dietary data in a standardized fashion (14). The multiple-pass interview technique was used to prompt children for complete food recall and descriptions. A variety of food-portion visual aids were available for use by participants in reporting portion size. Centralized training, certification of data collectors, and quality control were provided by staff at the University of Minnesota Nutrition Coordinating Center. To minimize the likelihood of bias in recording or reporting of food intake, intervention staff were not allowed to serve as data collectors.

Vendor products, menus, and recipes for food served in each school were collected for 5 days, including those days on which lunch observations and 24-hour dietary recalls were conducted. The menus and recipes were entered into the Nutrition Data System for Research and used as appropriate in the lunch observations and dietary recalls. Thus, nutrient intake calculations for the lunch observations and record-assisted 24-hour dietary recalls reflect as closely as possible the actual recipes and food preparation practices used at the child’s school, rather than fixed default values from the food database. This aspect was important because...
of the school food-service intervention activities and the varying recipes and food preparation practices among schools (15).

**Data analysis**

The cohort included in the analyses presented in this paper comprised study participants for whom 24-hour dietary recall and lunch observation measurements were collected concurrently during the final follow-up measurement period ($n = 608$).

Because of the sampling frame and study design, appropriate estimates of mean values, variances, and tests of differences required restricted maximum likelihood solutions for mixed models. Conceptually, the models allowed for comparisons between nutrient estimates derived from the two types of intake measures (observed and recall) in the same children. Children were nested within the 41 schools, schools within intervention conditions, and conditions within the four field sites. This structure allowed for correlations within nested groups and accounted for differences among groups. The resulting mixed models were constructed with PROC MIXED in the Statistical Analysis System (version 6.12; SAS Institute, Inc., Cary, North Carolina).

Regression parameters were derived from mixed models accommodating the study design features as described above. Of particular interest was the association of intervention conditions with systematic bias in reporting of nutrient intake, as estimated from recalled intake adjusted for observed intake in multiple regression analysis. For these regression analyses, nutrient intakes from recalls were the dependent variables; nutrient intakes from observations, child age, child gender, and intervention condition were fixed effects; and school and field site were random effects.

Because the distributions of intakes for specific nutrients departed substantially from a Gaussian distribution, power transformations were applied to approximate normality, and tests of significance were conducted on the transformed variables. For the analyses, intakes of saturated fatty acids, iron, vitamin C, and $\beta$-carotene were log-transformed, and intakes of carbohydrate, calcium, and vitamin A were square-root-transformed.

**RESULTS**

To examine the extent to which differences between reported and observed nutrient intakes for the lunch meal could be explained by intervention condition, we fitted linear regression models for each nutrient as follows: recall = observed + condition + sex + school(random) + site(random) = $e$. We included an intervention $\times$ sex interaction variable in the model to consider the possibility that bias in reporting might differ by sex. For all nutrients examined, the partial regression coefficients for intervention condition were not
TABLE 2. Average nutrient estimates from observed and recalled lunch intakes in girls, by treatment condition, Pathways Study, 1997–2000*

<table>
<thead>
<tr>
<th>Nutrient</th>
<th>Control (n = 148)</th>
<th>Intervention (n = 153)</th>
<th>Difference§</th>
<th>p value‡</th>
</tr>
</thead>
<tbody>
<tr>
<td>Total energy (kcal)</td>
<td>456.9</td>
<td>475.1</td>
<td>−18.4</td>
<td>0.03</td>
</tr>
<tr>
<td>Total fat (g)</td>
<td>16.3</td>
<td>15.4</td>
<td>0.5</td>
<td>0.02</td>
</tr>
<tr>
<td>Total fat (% of kcal)</td>
<td>30.8</td>
<td>29.3</td>
<td>1.8</td>
<td>0.09</td>
</tr>
<tr>
<td>Saturated fatty acids (g)</td>
<td>1.7</td>
<td>1.6</td>
<td>0.1</td>
<td>0.03</td>
</tr>
<tr>
<td>Saturated fatty acids (% of kcal)</td>
<td>11.6</td>
<td>11.2</td>
<td>0.4</td>
<td>0.14</td>
</tr>
<tr>
<td>Carbohydrates (g)</td>
<td>7.4</td>
<td>7.7</td>
<td>0.3</td>
<td>0.11</td>
</tr>
<tr>
<td>Carbohydrates (% of kcal)</td>
<td>50.4</td>
<td>54.1</td>
<td>0.3</td>
<td>0.11</td>
</tr>
<tr>
<td>Protein (g)</td>
<td>22.5</td>
<td>23.9</td>
<td>−3.4</td>
<td>0.11</td>
</tr>
<tr>
<td>Protein (% of kcal)</td>
<td>20.0</td>
<td>18.4</td>
<td>−1.6</td>
<td>0.60</td>
</tr>
<tr>
<td>Calcium (mg)</td>
<td>16.5</td>
<td>17.0</td>
<td>1.2</td>
<td>0.91</td>
</tr>
<tr>
<td>Iron (mg)</td>
<td>1.2</td>
<td>1.2</td>
<td>−0.1</td>
<td>0.20</td>
</tr>
<tr>
<td>Sodium (mg)</td>
<td>898.9</td>
<td>851.1</td>
<td>−47.8</td>
<td>0.21</td>
</tr>
<tr>
<td>Vitamin A (retinol equivalents)</td>
<td>14.3</td>
<td>14.5</td>
<td>0.2</td>
<td>0.18</td>
</tr>
<tr>
<td>Vitamin C (mg)</td>
<td>2.6</td>
<td>2.5</td>
<td>0.0</td>
<td>0.77</td>
</tr>
<tr>
<td>β-carotene (µg)</td>
<td>5.8</td>
<td>5.7</td>
<td>−0.1</td>
<td>0.49</td>
</tr>
</tbody>
</table>

* Data on saturated fatty acids, iron, vitamin C, and β-carotene were log-transformed; data on carbohydrates, calcium, and vitamin A were square-root-transformed.
† Difference between the differences between the means of control and intervention groups.
‡ p value for intervention condition in linear regression model.
§ Difference = recalled – observed.

Statistically significant; however, a significant intervention × sex interaction was found in the models predicting reported protein intake (p = 0.05) and reported iron intake (p = 0.05). In addition, a marginal intervention × sex interaction was found in the models predicting energy intake (p = 0.08) and total fat intake (p = 0.07). Accordingly, we reran the regression analyses by sex to further examine the possibility that intervention-related bias in reporting of intake may differ by sex (see tables 1 and 2 for p values). Results of these analyses (data not shown) indicated that among females, intervention condition was a significant predictor of reported energy, fat, and saturated fatty acid intakes. More specifically, independently of observed intake, reported energy intake among females in the intervention schools was 66.8 kcal lower than reported intake among females in the control schools (p = 0.03). With respect to total fat, independently of observed intake, reported fat intake among females in the intervention schools was 3.8 g lower than reported intake among females in the control schools (p = 0.03). Reported saturated fatty acid intake among females in the intervention schools was also significantly lower than reported intake among females in the control schools.

Tables 1 and 2 present the differences in observed and recalled lunch intake estimates by treatment condition among boys and girls, respectively. The findings presented in these tables are consistent with the results of the linear regression analyses.

DISCUSSION

These results suggest that intervention-related bias in reporting of dietary intake may be of concern among girls. More specifically, girls in intervention schools were found to systematically underreport energy, total fat, and saturated fatty acid intake relative to girls in the control schools. Among boys, no evidence of intervention-related bias in reporting of intake was found. The most likely explanation for the differential reporting of intake by intervention condition relates to social desirability bias in reporting, which may be greater among children in the intervention schools, where healthy eating and low-fat food alternatives were emphasized as part of the classroom curriculum. Indeed, the finding of underreporting by girls is consistent with the results of Hebert et al. (16), who found that adult women underreported total energy intake: A one-unit increase in social desirability score was associated with underestimation of 19.2 kcal/day in energy intake and 0.8 g/day in total fat intake. Hebert et al. have also reported that women generally rank higher than men in measures of social desirability. Moreover, conflict and guilt regarding food consumption occur more in girls than in boys (17).

Several limitations of this study should be noted. Because participants in this study were American Indian children from seven American Indian communities, strictly interpreted, these findings may be generalized only to similar
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Second, because participants provided a 24-hour dietary recall subsequent to being observed eating lunch, reporting may have been influenced by the observation, with participants providing more accurate reporting of intake because of increased attention to their diet.

In conclusion, these findings suggest that investigators should consider bias in reporting of dietary intake by intervention condition when conducting diet-focused intervention studies, in addition to the equally valid concerns about cognitive and social desirability biases in dietary reporting in epidemiologic studies. Intervention-related bias in reporting of dietary intake could potentially yield artifactual study results. In designing intervention studies, enhancement of measures that rely on self-reports with objective measures of dietary intake would help investigators to evaluate whether differential reporting by treatment group has occurred.

REFERENCES