I, Stacie L. Horner, hereby submit this work as part of the requirements for the degree of:

Master of Science

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It is entitled:

Assessing Dietary Variety in School-aged Children: Can Three 24-hour Interval and Consecutive Diet Recalls Predict Dietary Variety Similar To 15 Days of 24-hour Diet Recalls?

This work and its defense approved by:

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Assessing Dietary Variety in School-aged Children: Can Three 24-hour Interval and Consecutive Diet Recalls Predict Dietary Variety Similar to 15 Days of 24-hour Diet Recalls?

A thesis submitted to the
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by

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Abstract

Objective: Confirm addition of dietary variety slows after 15 days; determine whether three interval 24-hour recalls can capture dietary variety similar to the gold standard 15 days and better than 3 consecutive days.

Subjects: Recruited from an elementary school and included children aged 9-12 (n=72).

Methods: Fifteen 24-hour recalls were obtained for each subject and three scores calculated for each student: 15 consecutive, 3 interval, and 3 consecutive-day dietary variety scores (DVS). 15-day DVS were predicted from 3 days.

Results: Dietary variety levels off after 15 days. Average 15-day cumulative DVS was 43.3; three-day averages were 20.4 and 18.6 from interval and consecutive-day methods respectively. Average predicted 15-day cumulative DVS was 43.4 and 42.5 from 3 interval and 3 consecutive days respectively.

Conclusion: DVS can be predicted from 3 days using predictive equations and interval day method was more accurate and precise. This study created and validated predictive equations for 4th and 5th grade population.
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Major causes of morbidity and mortality in the United States are related to the poor diet and sedentary lifestyle of Americans. Consuming a wide array of different foods has been related to a lower risk of chronic diseases including heart disease and cancer and a reduced risk of all-cause mortality (1, 2). Despite current recommendations to increase dietary variety, only 33% of the US population consumes foods from all five food groups daily according to the second National Health and Nutrition Examination Survey (NHANES II) (3).

Since 1980, the US Department of Agriculture and the Department of Health and Human Services have released Dietary Guidelines for Americans every 5 years. The Dietary Guidelines have recommended eating a variety of foods on a daily basis from the beginning as one of the 7 guidelines. Dietary variety is believed to be essential for an optimal diet and promotion of health (2,4). The original guidelines from 1980 and the next published guidelines in 1985 encouraged the population to “Eat a variety of foods” (5,6). In 1990, the vague guideline was changed to a more specific recommendation “Choose a diet with plenty of fruits, vegetables, and grain products” (7). These Dietary Guidelines from 1980, 1985, and 1990 discussed the importance of dietary variety as a way to avoid deficiencies and/or excess amounts of any single nutrient. The guidelines encouraged selecting foods from each of the major food groups: fruits and vegetables; cereal, bread, and grains; meat, poultry, eggs, and fish; dried peas and beans; and milk, cheese, and yogurt. The 1995 Dietary Guidelines added the importance of eating different foods within each of the different food groups. For example, some fruits and vegetables are good sources of vitamin A or vitamin C while others are high in folate (8). In 2000, new dietary guidelines were added, one of which was “Choose a variety of grains, especially whole grains” (9). Because greater dietary variety may increase energy intake, the 2005 Dietary Guidelines recommend focusing
on healthy variety or advise to “Consume a variety of nutrient-dense foods and beverages within and among the basic food groups while choosing foods that limit the intake of saturated and trans fats, cholesterol, added sugars, salt, and alcohol” (10, 11, 12). The 2005 Dietary Guidelines also provide specific recommendations to consume more foods from certain food groups or advise to “Choose a variety of fruits and vegetables each day” and “Choose a variety of grains daily and at least half of the grains should come from whole grains” (12). The USDA Food Guide, My Pyramid 2005 embraces these principles of healthy dietary variety (13).

**Dietary Variety**

Dietary variety is defined as the number of different foods consumed within or across each of the food groups. One problem often sited for the lack of compliance to nutritional dietary recommendations to increase dietary variety may be the public’s confusion over the concept (14). The population may not be increasing dietary variety because the definitions of dietary variety often differ and can be interpreted in a number of ways by the population. The blanket statement “increase dietary variety” often leads to an increase in unhealthy dietary choices or foods with a low nutrient density and high energy content such as sweets, desserts, snacks, and condiments. On the other hand, an increase in nutrient-dense foods such as fruits, vegetables, and whole grains provide substantial amounts of vitamins and minerals and relatively few calories. These “healthy” choices need to be increased in American’s diets to increase overall diet quality and offering health benefits such as lower body weight and blood pressure. Recent studies reported an increase in unhealthy variety is associated with a higher BMI and a high percentage of body fat in both men and women (14). Not only is there healthy and unhealthy dietary variety but also among and within food group dietary
variety. Within group variety refers to variety of different choices within a particular food group (14). For example, the consumption of broccoli, carrots, and squash from the vegetable group is within group variety. Adherence to this recommendation may result in adequacy in intake of essential nutrients and other potentially beneficial substances (12). Among food group variety refers to incorporating foods from each of the five different food groups in a 24-hour period. For example, consuming grains, dairy foods, vegetables, fruits, and meats in a particular day represents among group variety (14). This type of variety is essential as each basic food group is a major contributor of at least one essential nutrient and may substantially contribute to dietary adequacy of other nutrients (12).

**Data Collection Instruments**

One of the most frequently used methods to measure dietary variety is the 24-hour recall. A 24-hour recall can be defined as a method of dietary assessment whereby an individual is asked to recount all foods and beverages consumed during the previous 24 hours (15). 24-hour recalls offer an advantage over other methods as the recall is administered after the food has been consumed so there is less potential for the assessment to interfere with normal dietary intake (15). The validity of the 24-hour recall has been tested with mixed results (16, 17). In general, estimates of intake using 24-hour recalls have been similar to observed intake. However, individuals with lower observed intakes tend to overreport the amount of food consumed and those with higher observed intakes tend to underreport their dietary intake, which is referred to as the “flat slope syndrome” (15, 16, 17).

Other methods used for the collection of dietary intake have had their validity and reliability debated and tested over the years (3, 14, 18, 19, 20, 21). However, according
to Kohlmeier few are satisfied or comfortable with the quality of the current methods, especially with regards to estimating dietary variety (22). This is especially true when it comes to children as relatively few studies have assessed dietary variety let alone dietary variety in children (23). Increasing evidence is showing that food patterns established in childhood will carry over into adulthood (22). Therefore, not only is it necessary that an inexpensive, valid, user-friendly tool be identified to assess dietary variety, but a tool that examines early childhood food habits and behaviors that are related to dietary variety is even more useful and prudent. Assessing a child’s food intake presents unique challenges compared to adults. Children often change what they are eating and have food “jags” where only a few items are consumed over a period of time, which ultimately may affect their dietary variety. Children are not as cognitively developed as their adult counterparts and tend to have a lack of knowledge about food measurement, lack of experience in food preparation, and short attention spans all of which increase the difficulty of obtaining valid food intake data (21, 24). The 24-hour recall approach to collecting dietary intake data has been validated in children (25); however, results from some studies show a high number of phantom foods, or foods not eaten but recorded, and missing foods that were eaten reported by children using 24-hour recalls (21, 26). The respondent burden of food records discussed previously makes food records an ineffective means of collecting dietary information from children. More complicated methods of dietary collection such as direct observation of a subject eating and biomarkers of intake are currently considered the most valid tools for assessing children’s dietary intake (21, 27). However, they are expensive, measure short-term intake, and would not be useful for assessing dietary variety as a goal. Children ages 9-11 have been shown to be able to report dietary intake on their own without the assistance of their parents or guardians (26, 28). The need for validated methods to
assess children’s dietary intake has been emphasized repeatedly in nutrition research and this study addresses this particular need with a focus on measuring dietary variety.

**Measuring Dietary Variety**

Dietary variety is determined by counting the number of novel foods, a food that has not been previously eaten during the study, eaten in a particular day or study period. For example, over 15 days if a subject eats an apple, it will only be recorded once even if it is eaten every day. The present methods available to categorize dietary variety are actually based on measuring overall diet quality with dietary variety as a component of the overall score. These methods are also meant to be population based as opposed to means of measuring an individual’s diet quality or variety. The methods include the Healthy Eating Index (HEI), the Diet Quality Index (DQI), and the Diet Quality Index Revised (DQI-R). The HEI, DQI, and DQI-R are based on the foods consumed by an individual over a three-day period utilizing a single 24-hour recall and 2 food records (29, 30, 31). An individual must eat at least half of a food group serving in a 24-hour period for that particular food to count towards the analysis of diet quality. Foods are broken down into food groups and the number of different foods consumed in each food group is totaled. The HEI is a 100-point scale that is used to rank an individual’s quality of diet. A higher number indicates better diet quality. Points are given on a scale of 0-10 for each of the 5 food groups. The remainder of the 100 points is given based on compliance with the USDA and HHS Dietary Guidelines with regards to total fat, saturated fat, dietary cholesterol, and sodium intake. The final category is dietary variety (29). The DQI is another measure of overall diet quality. There are eight diet variables with a score of 0-2 given in each category. The categories include total fat, saturated fat, cholesterol, fruit and vegetable, starch, protein, sodium and calcium intake.
The possible overall score ranges from 0-16 with a lower score indicative of better quality of diet (30). The DQI-R was introduced later to incorporate the new dietary guidelines and the concept of “healthy” dietary variety and moderation. Additionally, the DQI-R expanded the scoring of the original scale to a 100-point scale and reversed the direction, similar to the HEI (31). These three methods are based on either only one or three days of dietary information and Drewnowski’s and Olenszki’s research has shown even three days may not provide the necessary time to reflect the true extent of dietary variety of an individual (15, 27, 32).

Typically, dietary assessments are based on one to three days of dietary data. Nelson demonstrated that seven consecutive days of dietary data was not enough to accurately capture an individual’s dietary variety (33). Drewnowski et al. determined 15 days of dietary intake data captures the extent of an individual’s dietary variety or the maximum amount of different foods in an individual’s diet (15, 34). In response to the increased attention in the literature on dietary variety, Drewnowski et al. developed a new tool to measure dietary variety alone called the Dietary Variety Score (DVS). This tool was developed with an adult population and involves 15 consecutive days of dietary data. In Drewnowski’s study, a 24-hour diet recall was done on the first day followed by 14 consecutive food records. The number of different foods consumed over time was added together to create the DVS. This method also included a modified 5-point DQI scale that looked at total fat, saturated fat, cholesterol, sodium and carbohydrate (34).

After 15 days, the addition of novel or new foods tapers off seeming as though no more significant variety is added to the diet. The current “gold-standard” technique for measuring dietary variety is 15 consecutive days of dietary data. There are no methods available to adequately capture dietary intake over this necessary time period without being cumbersome and time consuming to both the participants and medical
professionals (20, 35, 36). The DVS provided a starting point from which a new tool could be developed.

**Study Purpose**

The purpose of this study was to first confirm previous findings, which showed intake of dietary variety tends to trend towards leveling off after 15 days. Another purpose of this study was to determine whether three days of 24-hour dietary recalls chosen from 3 intervals within 15 consecutive days would capture an individual’s dietary variety as well as the gold standard of 15 consecutive days of dietary recalls. Additionally, the study was designed to determine if 3 interval days of 24-hour dietary recalls could capture an individual’s dietary variety better than 3 consecutive (first) days of dietary recall. The hypothesis was that the cumulative dietary variety score from a 24-hour recall within three different intervals would positively correlate with the cumulative dietary variety score from fifteen consecutive 24-hour recalls. Three days of dietary collection was picked as the study’s aim because it is the minimum amount of dietary data needed to characterize usual intake, it is a feasible amount of recalls that can be done in an actual setting and it reduces burden (35). Additionally, it was hypothesized that the 3 interval day cumulative dietary variety score would correlate better with the cumulative 15 consecutive day dietary variety score than the 3 consecutive day cumulative dietary variety scores from three consecutive days of 24-hour recalls. A new question was then proposed: If the 3 day dietary variety scores are lower than the 15-day cumulative dietary variety scores, can 15-day cumulative dietary variety scores be accurately and precisely *predicted* from measuring dietary variety on 3 interval days and 3 consecutive (first) days? The significance of this study is if an accurate, less time consuming tool for assessing dietary variety could be identified, patients, could be
screened in less time and population assessments can be cheaper and more reliable.

**STUDY PROCEDURES**

**Subjects**

Our target population was children above the age of nine. According to the literature, prior to the age of 9 children are not developed enough mentally to accurately report and record their dietary intake independently (24). The study population was recruited from the IDA Weller Elementary School in Centerville, Ohio. This school is a public school in middle to upper class, suburban school district. The student population consisted of mainly white, non-Hispanic students. All 4th and 5th grade teachers were asked to allow their students aged 9-12 to participate in the study. There were four fourth grade classes and four fifth grade classes for a total of 200 possible students (37). Seven of the eight teachers agreed to participate in the study for a total of 175 students or 87.5% of the total students. The parents of the eligible students were mailed consent forms with an explanation of the study prior to study initiation (Appendix A). Out of the 175 eligible students, 109 parents signed consent forms and agreed to let their children be part of the study. The study began on the second day of classes of the 2003-2004 academic year.

On the first day of the study, students with completed parental consent forms signed an assent form assenting that they were willing to be part of the study. At this time students completed a demographic information form (Appendix B and C). The researchers then collected the height and weight of each child participating and calculated their BMI.
Design

This study was designed to measure 15 consecutive days of dietary intake utilizing 24-hour recalls. The students were unable to participate if the informed consent and/or assent were not obtained. Prior to the start of the study, registered dietitians educated all students in the 4th and 5th grade classrooms on how to fill out the 24-hour food recall form (Appendix D). In each classroom, the students were taught how to estimate portion sizes using food models and food portion educational posters (38), which remained in the classroom for reference for the duration of the study. Measuring devices such as cups and teaspoons were shown to the students to aid in estimation of portion sizes at home. In addition, children received a handout to help them correctly estimate portion sizes. No education regarding the importance of eating a variety of foods was done at this time. Per teacher request, all students were instructed on how to complete a 24-hour recall and estimate portion size regardless of study participation. All students received small gifts such as pencils, stickers, etc. after completing the assigned task. The gifts were given to every student in the classroom regardless of participation in the study or completion of the 24-hour recalls.

By the end of the study each participating student was asked to fill out a total of fifteen consecutive 24-hour recalls. Collection of data started on a Tuesday and continued for 15 consecutive days. This enabled the collection of dietary information on weekdays and two weekends. Subjects remained in their own classroom and were given adequate time to complete the recalls each day of the study. A dietitian started in the same classroom every morning of the study and once their recalls were complete, the dietitian went to the next classroom and started the 24-hour recalls. This continued until all seven classrooms were visited. Students worked independently and quietly and did not share their food recalls with other students. Each classroom was supervised by at
least one dietitian while the students completed their 24-hour recall. The dietitian asked a set of standardized questions each day to the entire classroom while the 24-hour food recalls were completed. The preset questions probed the students to remember their previous days’ intake as well as ensure consistency between the 2 different dietitians and 7 classrooms (Appendix E). For example, the first question was “Everyone think about when you woke up yesterday, did you have anything to eat or drink? If so, write it down.” The dietitians answered any of the subject’s questions individually and privately as well as assisted in completion of the recalls if necessary. The forms were collected once all children were finished filling out their recalls. The students that were not participating read or worked quietly during this time. This was repeated on each school day. On the weekends, the children were given the appropriate number of recall forms and asked to complete them each day over the weekend. An instruction sheet was attached to the front of the recall sheets to prompt the children as if they were in the classroom with the researchers. The researchers phone numbers were provided to the subjects in case any questions should arise over the weekend. The children then returned their weekend recalls the next day of school. If a child was not in the classroom at the time of the recall but would be there later in the day, they were allowed to complete the recall when they returned. In addition, if the students forgot to bring back their weekend recall forms, they were able to bring them by the end of the study period.

The teachers were not made aware of those students who did not participate or failed complete the recalls. Students recorded their name on their recalls and once the data was collected, each student was assigned a number so his or her name was deleted and not utilized, to ensure anonymity. All recalls were stored in a confidential place. Any data stored on computers was only accessible by the researchers with use of a password.
**Dietary Variety Scores**

Once all fifteen 24-hour recalls were obtained for each subject, the researchers ultimately calculated three different *cumulative* dietary variety scores for each student: 15 consecutive day (DVS$_{15}$), 3 interval day (DVS$_{3I}$), and 3 consecutive day (DVS$_{3C}$). All foods and beverages eaten by each student were separated into the appropriate food groups and then added together. The 24-hour recall form used for the study is shown in *Appendix A*. It was peer reviewed to ensure its accuracy. What constitutes a serving size was defined according to the USDA Food Guide, My Pyramid 2005 recommendations. For example, a serving of fruit equaled one whole medium size fruit, ½ cup of cooked or canned fruit or ¾ cup of 100% fruit juice. A vegetable serving consisted of 1 cup raw leafy or ½ cup cooked or chopped vegetables. A serving of grain equaled one slice of bread, ½ a hamburger bun, or ½ cup cooked cereal, rice or pasta. A serving of dairy equaled 1 cup of milk or yogurt and 1½ ounces of cheese. A serving of meat equaled 2-3 ounces of meat, poultry or fish or ½ cup dried beans, 1 egg or 2 tablespoons of peanut butter equaled 1 ounce of meat. A student had to eat at least one half of a serving for that particular food or beverage to be counted in the dietary variety score. The Healthy Eating Index (HEI) guidelines and coding system for estimating dietary variety were used in this study (29). All fruits and vegetables were counted separately unless they were different forms of the same fruit or vegetable. For example, potatoes and French fries were counted as the same item as were apples and applesauce. 100% fruit juice was counted the same as the fruit it contained. All white bread products were counted the same (white bread, rolls, etc.). Breadsticks and pizza crust were considered the same item and therefore only counted as 1 in the dietary variety score. Pepperoni pizza however was separated into crust, cheese, and meat groups and each item was counted. Whole-wheat products were counted separately from white
flour products. Different forms of the same meat were counted as the same (Steak and ground beef for example). Most fluid milk was counted as the same item as well as different forms of cheese with the exception of cottage cheese. Ice cream and yogurt were counted separately from milk and cheese (29).

**Intervals**

From previous research on dietary variety it was noted that the rate at which foods are added is not constant over 15 days (34). A sharp increase has been noted in the first 3-4 days, which slowed by the 10th day and eventually leveled off after 15 days. Therefore, it seemed necessary to split the fifteen days into three equal intervals, which would later be used to capture the 3 interval day dietary variety score. The fifteen days were split into three different intervals as follows: Interval 1 contained study days 1-5; Interval 2 contained study days 6-10; and Interval 3 contained study days 11-15. For example, a subject ate 14 novel foods in the first interval, 8 novel foods in the second interval, and only three novel foods during the third interval. The median number of novel foods added per day in Interval 1 is 3. (Determined by subtracting the median dietary variety score on day 1 for all subjects from the median dietary variety score on day 5 and dividing by 5 total days). The median number of novel foods added per day in Interval 2 is 1.4 (day 6 subtracted from day 10 divided by 5) and in Interval 3 is 1.0 (day 11 subtracted from day 15 divided by 5).

**15 Consecutive Day Cumulative Dietary Variety Score**

15 consecutive days were utilized because of the leveling off effect seen in previous studies which indicated no novel foods or very few would be added after 15 days and contribute to the dietary variety score (30). The 15-day cumulative dietary variety score
was calculated by determining the number of different foods and beverages consumed from the 24-hour recall on the first day of the study. This number of different foods and beverages represented the cumulative dietary variety score for Day 1 or DVS\textsubscript{1}. On each additional day of the study the number of new or different foods or beverages consumed was added onto the first day’s dietary variety score. For example, if a subject ate 10 different foods on the first day of the study and ate 8 novel foods on the second day, the variety score on day one (DVS\textsubscript{1}) would be 10 and the variety score on day two (DVS\textsubscript{2}) would be 10 plus the 8 novel foods or 18. Day 3 the cumulative dietary variety score was 21 (DVS\textsubscript{3}), day 4 the score was 23 (DVS\textsubscript{4}) and day 5 the score was 24 (DVS\textsubscript{5}) meaning 3 novel foods, 2 novel foods and 1 novel food were added each day respectively. The cumulative dietary variety scores are 24, 25, 26, 31, and 32 for days 6-10 respectively (DVS\textsubscript{6}-DVS\textsubscript{10}). The scores are 32, 33, 34, 36, and 37 for days 11-15 respectively (DVS\textsubscript{11}-DVS\textsubscript{15}). Therefore, the 15-day cumulative dietary variety score for this subject was 37 (DVS\textsubscript{15}). This method was repeated until a 15-day cumulative dietary variety score was obtained for each student.

3 Interval Day Cumulative Dietary Variety Score

As previously mentioned, the number of novel foods added is not consistent over the three different time intervals. This demonstrates why it was necessary to choose a day within each of the three intervals to predict a more accurate 15-day variety score from 3 days of dietary intake data, instead of simply looking at the first three consecutive days of dietary intake. The 15 days of dietary intake were divided into three sections of five days each, and a random day was selected within the first interval (study days 1-5) based on the random numbers table (Table 1) designed by Levin (39). The next two 24-hour recalls were selected 5 days spaced out from the original randomly chosen day. The
equidistance was done to obtain a variety estimate that equally represented the three
time intervals. For example, if study day 2 was randomly selected for subject 1, the next
two days of recalls that were analyzed were study day 7 and 12. Three random days of
recalls were chosen for each student. 15 consecutive days was utilized as opposed to
spreading the random days out longer say over 3 weeks because as previously
mentioned Drewnowski et al. showed that dietary variety does not increase after 15
consecutive days (34). The dietary variety score on day 2 alone was 14. Note this is
different from the cumulative dietary variety score on day 2, which also includes the
subject’s intake from day 1. The number of novel foods on day 7 alone when compared
to foods already consumed on random day 2 was 5 for a random cumulative dietary
variety score of 19 when added to dietary variety score of 14 from day 2. On day 12 of
the study, 3 novel foods were added when intake was compared to random days 2 and 7
for a total 3 random day cumulative dietary variety score of 22 (DVS$_{31}$).
Table 1. 
Table Used to Select the Initial Day and Two Subsequent Days for Calculating the Interval 3-Day Cumulative Dietary Variety Score a

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a Apply table beginning with subject 1 and repeating for every 25 subjects 
b First Interval = Days 1-5, Second Interval = Days 6-10, Third Interval = Days 11-15. 
c Example: The first subject would have the 24-hour diet recalls for days #1, 6, and 11 used for analysis to compute cumulative dietary variety scores for interval 1, 2, and 3 respectively.

3 Consecutive Day Cumulative Dietary Variety Score

The three consecutive (first) day dietary variety score was defined as the cumulative dietary variety score on the third day of the study (DVS_3). For each student a dietary variety score was calculated for day 1 of the study and the number of novel foods and beverages from day 2 were added onto the dietary variety score from day 1. This was
repeated for the third day of the study and the resulting number was the 3 consecutive
day cumulative dietary variety score (DVS_{3C}).

**Statistical Analysis**

Three types of cumulative dietary variety scores were calculated for each of the 72
students. The first two types consisted of scores obtained on three different days within
a 15-day period. The days of collection of the first type, 3 *interval*-day cumulative
dietary variety, were approximately equally spaced over the 15-day period. The first
day was randomly chosen from the first 5 days (beginning of the study); scores on the
next two days were obtained about 5 and 10 days later. The three days of collection of
the second type, 3 *consecutive*-day cumulative dietary variety, were consecutive,
beginning on day one. The third type of cumulative score was equal to the value of the
15^{th} consecutive days cumulative variety score, beginning on day one. If a diet recall
and therefore a diet variety score were missing during the 15-day period, the missing
value was imputed in order to have complete data for analysis (40). Imputation was
subject-specific. This was carried out by imputing a missing value from known data of
the same subject by using scores on the days *preceding* the day of missing data. For
example, if subject 1 was missing a cumulative variety score on day, regression analysis
was carried out to estimate the value on day 10 from regression coefficients, which were
based on data from other subjects. The regression coefficients were then applied to the
data of subject 1 on days one through nine in order to estimate the value on day 10. The
cumulative variety score for subject 1 on day 11 was also adjusted to be consistent with
the change between days 10 and 11 for other subjects. Succeeding scores for subject 1
were adjusted from the value on day 11, keeping the same distance between scores on
consecutive days. Therefore, the new imputed number changed the variety score for all
days after (Appendix E).

Using 3 interval and 3 consecutive-day cumulative dietary variety scores, a 15-day dietary variety score was predicted from regression equations. The averaged predicted results from 3 interval and 3 consecutive-day methods were then compared to the averaged observed results for cumulative 15-day dietary variety scores. Mean bias, equal to the difference between the means of observed and predicted scores of 15-day dietary variety were calculated for interval and consecutive 3-day scores. Correlations between the predicted and observed values of 15-day dietary variety with a 95% confidence interval were calculated. Mean squared errors or the average of the sum of squared differences between the observed and predicted values of 15-day dietary variety were calculated. In order to validate the results, the two grade levels 4th and 5th were compared. The data obtained for the 4th graders were inserted into the predictive equations developed for the 5th graders and vice versa. Mean bias, correlation with a 95% confidence interval, and mean squared errors were also calculated for the validation studies.

In order to prove the model fit, the outcome (15-day dietary variety score), and the two 3-day dietary variety scores (independent variables) were loge transformed from the linear scale to the additive scale. From these analyses, two different equations were developed: one equation to be used for the interval scores and one equation for the consecutive scores. Four regression coefficients were obtained for each type of analysis, corresponding to the center of the observed data (intercept) and the effect or relative weight of each day’s score on the outcome. The coefficients were different for each type of score because the rate of addition of new foods was not the same between interval and consecutive days.

Cross validation studies were performed to validate the results by determining the
weights from the 5th graders and applying them to the 4th graders. Predicted 15-day dietary variety scores were then calculated for the 4th graders from the regression coefficients of the 5th graders. The observed and predicted 15-day dietary variety scores of the 4th graders were then compared. The same was done using weights from the 4th graders and applying them to the 5th graders dietary variety scores.

The regression coefficients developed from this study apply to 4th and 5th graders. Statistical analyses were performed using the Statistical Analysis Systems (SAS) software, version 8.02 (41).

**DESCRIPTION OF FINDINGS**

**Characteristics of the Subjects**

Out of the 109 students that started the study, eight (7%) dropped out during the study for a completion rate of 97% of total students. Out of these 101 students that completed the 15-day study, 29 were discarded for a remainder of 72 total students or 67% of the students that began the study that were utilized for analysis. Twelve students were eliminated from the study because they missed greater than five days of dietary recalls due to absence from school or forgetting weekend records. Five students were dismissed from the study because their recalls were incomplete. Fifteen students were dismissed from the study because they were missing a dietary recall on one or more of the random days they were assigned. In terms of ethnicity, two students were African-American, one was Mexican-American, and the remaining 106 students in the study were Caucasian. From the 72 total students used for analysis, a cumulative dietary variety score for each of the fifteen days was determined for every student. The final result was a 15-day cumulative dietary variety intake score for every student (N= 72).
**Results**

There was a variation in dietary variety scores among the different subjects included in the study. The following tables are examples of how all three dietary variety scores were calculated for a student with the highest cumulative DVS_{15} (=55) as compared to a student with the lowest cumulative DVS_{15} (=32) (Table 2A and 2C). The 3 *interval*-day dietary variety score (DVS_{3I}) example is shown in Table 2B and 2D. The 3 *consecutive*-day dietary variety score (DVS_{3C}) is simply the first three days of the study as shown in Table 2A and 2C.

---

**Table 2A. Calculation of 15 and 3 Consecutive-Day Cumulative Dietary Variety Scores:**

*Subject with a *High* Intake of Dietary Variety*

(Subject #6)
15-Day D.V.S. = 55
3 Consecutive Day D.V.S = 14

<table>
<thead>
<tr>
<th>Day 1</th>
<th>2</th>
<th>3</th>
<th>4</th>
<th>5</th>
<th>6</th>
<th>7</th>
<th>8</th>
<th>9</th>
<th>10</th>
<th>11</th>
<th>12</th>
<th>13</th>
<th>14</th>
<th>15</th>
</tr>
</thead>
<tbody>
<tr>
<td>Wheat bread</td>
<td>Pretzel</td>
<td>Cornflake</td>
<td>Potato</td>
<td>Grapes</td>
<td>OJ</td>
<td>Milk</td>
<td>Bologna</td>
<td>Chicken</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Day 1</td>
<td>Cheerios</td>
<td>Granola bar</td>
<td>Lettuce</td>
<td>Fish</td>
<td>Apple</td>
<td>Egg</td>
<td>Chocolate</td>
<td>Cookie</td>
<td>White</td>
<td>bun</td>
<td>Cheese</td>
<td>-its</td>
<td>Carrots</td>
<td>Plum</td>
</tr>
<tr>
<td>Day 1</td>
<td>Waffle cone</td>
<td>Brown rice</td>
<td>Cucumber</td>
<td>Green beans</td>
<td>Ice cream</td>
<td>Pine nuts</td>
<td>Pasta</td>
<td>Corn</td>
<td>Tuna</td>
<td>Mayo</td>
<td>Candy</td>
<td>Capri</td>
<td>Sun</td>
<td></td>
</tr>
<tr>
<td>Day 1</td>
<td>Rice</td>
<td>Zucchini</td>
<td>Cream sauce</td>
<td>Popcorn</td>
<td>Onion</td>
<td>Cabbage</td>
<td>Prune</td>
<td>Beef</td>
<td>Cream cheese</td>
<td>Cauliflower</td>
<td>Green pepper</td>
<td>Banana</td>
<td>Pineap</td>
<td></td>
</tr>
</tbody>
</table>
Table 2B. Calculation of 3 Interval-Day Cumulative Dietary Variety Score:
Subject with a *High* Intake of Dietary Variety

*(Subject #6)*

3 Interval Day D.V.S. = **28**

<table>
<thead>
<tr>
<th>Interval 1 (Day 1)*a</th>
<th>Interval 2 (Day 6)*a</th>
<th>Interval 3 (Day 11)*a</th>
</tr>
</thead>
<tbody>
<tr>
<td>Wheat bread</td>
<td>Ice cream</td>
<td>Cheese</td>
</tr>
<tr>
<td>Pretzels</td>
<td>Green beans</td>
<td>Onion</td>
</tr>
<tr>
<td>Cornflakes</td>
<td>Tomato</td>
<td>Popcorn</td>
</tr>
<tr>
<td>Potato</td>
<td>Cucumber</td>
<td>Turkey</td>
</tr>
<tr>
<td>Grapes</td>
<td>Broccoli</td>
<td>Juice Drink</td>
</tr>
<tr>
<td>OJ</td>
<td>Cheerios</td>
<td>Olive Oil</td>
</tr>
<tr>
<td>Milk</td>
<td>Cookie</td>
<td></td>
</tr>
<tr>
<td>Bologna</td>
<td>Brown Rice</td>
<td></td>
</tr>
<tr>
<td>Chicken</td>
<td>Cheese-it Crackers</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Waffle Cone</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Granola Bar</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Apple</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Pine Nuts</td>
<td></td>
</tr>
</tbody>
</table>

D.V.S. = **9**

D.V.S. = **22**

D.V.S. = **28**

*a Day 1, 6, and 11 were the three days chosen using the Random Numbers Table (Table 1).*

Table 2C. Calculation of 15 and 3 Consecutive-Day Cumulative Dietary Variety Scores:
Subject with a *Low* Intake of Dietary Variety

*(Subject #53)*

15 Day D.V.S. = **32**

3 Consecutive Day D.V.S. = **10**

<table>
<thead>
<tr>
<th>Day 1</th>
<th>2</th>
<th>3</th>
<th>4</th>
<th>5</th>
<th>6</th>
<th>7</th>
<th>8</th>
<th>9</th>
<th>10</th>
<th>11</th>
<th>12</th>
<th>13</th>
<th>14</th>
<th>15</th>
</tr>
</thead>
<tbody>
<tr>
<td>Oatmeal</td>
<td>Pretzels</td>
<td>OJ</td>
<td>Peanut butter</td>
<td>Chicken</td>
<td>Grapes</td>
<td>Milk</td>
<td>Beef</td>
<td>Pizza crust</td>
<td>Tomato</td>
<td>Cheese</td>
<td>Salami</td>
<td>Popsicle</td>
<td>Cake</td>
<td>Chili beans</td>
</tr>
</tbody>
</table>
Table 2D. Calculation of 3 Interval-Day Cumulative Dietary Variety Score: 
Subject with a Low Intake of Dietary Variety

*(Subject #53)*

3 Random Day D.V.S. = **14**

<table>
<thead>
<tr>
<th>Interval 1 (Day 4)*</th>
<th>Interval 2 (Day 9)*</th>
<th>Interval 3 (Day 14)*</th>
</tr>
</thead>
<tbody>
<tr>
<td>Milk</td>
<td>Potatoes</td>
<td>Tomato Sauce</td>
</tr>
<tr>
<td>Oatmeal</td>
<td>Mixed Vegetables</td>
<td>Pasta</td>
</tr>
<tr>
<td>White bread</td>
<td>Sausage</td>
<td></td>
</tr>
<tr>
<td>Orange Juice (100%)</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Grapes</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Meatloaf</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Peanut Butter</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Jelly</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Peanut Butter</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Oreo</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

D.V.S. = 9          D.V.S. = 12          D.V.S. = **14**

*Day 4, 9, and 14 were the three days chosen using the Random Numbers Table (Table 1).*

The average cumulative 15-day dietary variety scores for all 72 subjects are shown by the graph in Figure 1 and actual values are shown in Table 3. The average of all 72 students’ cumulative dietary variety scores with a 95% Confidence Interval was 43.3 [41.3, 45.3]. A 3 interval-day dietary variety score and a cumulative 3-day dietary variety score were also calculated for all 72 subjects. As expected, the consumption of different or novel foods increased over time. There was a sharp increase in novel food noted in days 1-3 and then the increase slowed and began to level off towards the end of 15 days.
Figure 1.

The Mean Observed Cumulative Dietary Variety Score with 95% Confidence Interval (CI) as it Increases Over 15 Days for All Subjects (N=72)

<table>
<thead>
<tr>
<th>Interval 1a</th>
<th>Interval 2a</th>
<th>Interval 3a</th>
</tr>
</thead>
<tbody>
<tr>
<td>0</td>
<td>5</td>
<td>10</td>
</tr>
<tr>
<td>15</td>
<td>20</td>
<td>25</td>
</tr>
<tr>
<td>30</td>
<td>35</td>
<td>40</td>
</tr>
<tr>
<td>45</td>
<td>50</td>
<td>55</td>
</tr>
</tbody>
</table>

Day of the Study

Mean Observed Cummulative Dietary Variety Score for all 72 Subjects (95% CI)

Table 3. a Actual values of information graphed in Figure 1.

<table>
<thead>
<tr>
<th>Study Day</th>
<th>Mean Cumulative Dietary Variety Score over 15 Days for all Subjects N=72 [95% Confidence Interval] a</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>9.7 [9.1, 10.3]</td>
</tr>
<tr>
<td>2</td>
<td>15.1 [14.2, 16.0]</td>
</tr>
<tr>
<td>3</td>
<td>18.6 [17.5, 19.7]</td>
</tr>
<tr>
<td>4</td>
<td>22.2 [21.1, 23.3]</td>
</tr>
<tr>
<td>5</td>
<td>26.1 [24.9, 27.3]</td>
</tr>
<tr>
<td>6</td>
<td>29.0 [27.6, 30.4]</td>
</tr>
<tr>
<td>7</td>
<td>31.5 [30.0, 33.0]</td>
</tr>
<tr>
<td>8</td>
<td>33.4 [31.9, 34.9]</td>
</tr>
<tr>
<td>9</td>
<td>35.3 [33.7, 36.9]</td>
</tr>
<tr>
<td>10</td>
<td>36.6 [34.9, 38.3]</td>
</tr>
<tr>
<td>11</td>
<td>38.1 [36.4, 39.8]</td>
</tr>
<tr>
<td>12</td>
<td>39.7 [37.8, 41.6]</td>
</tr>
<tr>
<td>13</td>
<td>41.2 [39.3, 43.1]</td>
</tr>
<tr>
<td>14</td>
<td>42.3 [40.3, 44.3]</td>
</tr>
<tr>
<td>15</td>
<td>43.3 [41.3, 45.3]</td>
</tr>
</tbody>
</table>

a The dashed lines separate the three separate intervals each from which a day was selected for a total of 3 days. (Interval 1 = Days 1-5, Interval 2 = Days 6-10, and Interval 3 = Days 11-15).
In comparison to the average of the 15-day cumulative dietary variety score of 43.3, the average of all 72 students’ 3 interval-day cumulative dietary variety score was 20.4 and the consecutive 3-day cumulative dietary variety score average was 18.6 (Table 5). The dietary variety scores obtained from three days of dietary data for both methods (interval and consecutive) were significantly less than the dietary variety score obtained from 15 days of dietary intake data, as predicted. This answered the question of whether 3 interval days and 3 consecutive days of dietary data were comparable to 15 consecutive days in terms of dietary variety. However, the 3 interval-day dietary variety score was closer to the 15-day dietary score than the 3 consecutive day dietary variety score was, as hypothesized. Since the method of capturing dietary variety only utilizing 3 days of dietary data may not capture the true extent of an individuals dietary variety, even when randomized, the method of utilizing only three days of dietary data needs to be predictive in nature.

<table>
<thead>
<tr>
<th>Table 4. Mean Observed Dietary Variety Scores of N=72 Subjects</th>
</tr>
</thead>
<tbody>
<tr>
<td>Observed 15-Day Cumulative Dietary Variety Score (N=72)</td>
</tr>
<tr>
<td>Mean [95% CI]</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Table 5A. Regression Coefficients (Constants) for Prediction Equations of 15-Day Dietary Variety a</th>
</tr>
</thead>
<tbody>
<tr>
<td>Method</td>
</tr>
<tr>
<td>-----------------------------------------------</td>
</tr>
<tr>
<td>Interval Days b</td>
</tr>
<tr>
<td></td>
</tr>
<tr>
<td>Consecutive Days c</td>
</tr>
<tr>
<td></td>
</tr>
</tbody>
</table>

a All values shown in Table 2A are constants estimated from the linear regression analysis model.
b The baseline value A and coefficients B, C, D were used in the study to obtain the Predicted 15-Day Cumulative Dietary Variety Score from the Cumulative Dietary Variety Scores of the three INTERVAL days.
c The baseline value E and coefficients F, G, H were used in the study to obtain the Predicted 15-Day Cumulative Dietary Variety Score from the Cumulative Dietary Variety Scores of the three CONSECUTIVE days.
The baseline value for the interval-day dietary variety was 2.12. The baseline value for the consecutive day method of predicting dietary variety was 2.36. The weights are necessary to obtain the best-predicted values or 15-day dietary variety scores from the independent variables (3-interval or 3-consecutive day dietary variety score data). For the 3 interval-day method, the constant coefficient for Interval 1 was –0.22, it was -0.19 for Interval 2, and it was 0.89 for Interval 3. For the 3 consecutive-day method, the constant for day 1 and day 2 was –0.06 and for day 3 was 0.58. Every subject’s dietary variety scores on each of the three chosen study days whether interval or consecutive were multiplied by a weight (coefficient) such that the sum of the weighted products was approximately equal to the observed 15-day cumulative variety score. The weights were the same for all subjects but different for the interval and consecutive days and were obtained from log linear regression analysis. The values are different for the 3-interval day data vs. the 3-consecutive day data simply because there were different variety scores for the interval vs. consecutive days. The results for the cumulative dietary variety of three random days and three consecutive days for each of the 72 subjects were used to obtain a predicted 15-day cumulative dietary variety score from the predictive equations.

Utilizing the baseline values and constants, the 3 days of dietary variety information that was collected either by the interval or consecutive-day method was entered into the appropriate predictive equation (Table 5B). The result is a predicted 15-day cumulative dietary variety score from only 3 days of dietary data.
Table 5B.
Equations used to Predict the 15-Day Cumulative Dietary Variety Score of a Subject from 3 Days of Dietary Recall Data for 3 Interval Days and 3 Consecutive Days

<table>
<thead>
<tr>
<th>Predictive Equation for 3 Interval Days:</th>
<th>15-Day Dietary Variety Score ← [A^a + (B^b * X^c) + (C^b * Y^c) + (D^b * Z^c)]^e</th>
</tr>
</thead>
<tbody>
<tr>
<td>Predictive Equation for 3 Consecutive Days:</td>
<td>15-Day Dietary Variety Score ← [E^a + (F^b * X^d) + (G^b * Y^d) + (H^b * Z^d)]^e</td>
</tr>
</tbody>
</table>

^a The values for A and E are the constant baseline values for 3 interval days and 3 consecutive day respectively.
^b The values for B, C, D are the coefficients designed for the 3 interval-day estimates for Intervals 1-3 respectively. The values for F, G, H are the coefficients designed for the 3 consecutive day estimates for Days 1-3 respectively (Table 2A).
^c X, Y, and Z = log_e of the INTERVAL-day cumulative dietary variety scores from Intervals 1, 2, and 3 respectively. For example, if the cumulative dietary variety score of Interval 1 was 8, X = log_e, 8 = 0.9
^d X, Y, and Z = log_e of the CONSECUTIVE day cumulative dietary variety scores from consecutive days 1, 2, and 3 respectively. For example, if the cumulative dietary variety score of Day 1 was 10, X = log_e, 10 = 1
^e Using a scientific calculator, coefficients B, C, D and F, G, H are multiplied by the log_e of the cumulative dietary variety score for each of the three days of dietary recall chosen by interval and consecutive-day methods respectively. The sum of the products is added to the baseline value. Thus, the right sides of the equations predict the log_e of 15-day cumulative dietary variety scores. Taking the anti-log of the right side result provides the dietary variety score on the original additive scale to obtain the predicted 15-Day Cumulative Dietary Variety Score.

X, Y, and Z are representative of the log_e of the various cumulative dietary variety scores. When multiplied by the constants and added to the baseline value, a 15-day dietary variety score was predicted on the additive scale. This value is the exponentiated from the additive log scale to the linear scale and an actual number for a predicted variety score was obtained. For example, a subject has the following cumulative dietary variety scores: Interval 1 = 9, Interval 2 = 14, and Interval 3 = 17. The predicted 15-day cumulative dietary variety score from these 3 values is:

Predicted 15-day DVS ← [2.12 + (-0.22 * log_e 9) + (-0.19 * log_e 14) + (0.89 * log_e 17)]
(A) (B) (X) (C) (Y) (D) (Z)

← [2.12 + (-0.22 * 0.954) + (-0.19 * 1.146) + (0.89 * 1.231)]

Predicted 15-day DVS = anti-log_e 1.58 = 38.7.

This value is on the additive scale and so taking anti-log on a scientific calculator gives a result of 38.7, which is the predicted 15-day cumulative dietary variety score on
The results for the 3 days of interval and consecutive dietary variety scores for all 72 subjects were entered into the appropriate predictive equations, which the study designed. Table 5C gives examples of two actual subjects and how the 15-day cumulative dietary variety scores were predicted from 3 interval and 3 consecutive days of dietary data. The predicted score was then compared to the observed dietary variety scores.

Table 5C.
Examples of Predicting 15-Day Cumulative Dietary Variety Scores using the Regression Coefficients in Table 4.B for Two Subjects. Predicted Values are Compared to Observed Values.

<table>
<thead>
<tr>
<th>Type of Prediction</th>
<th>Equation</th>
<th>Predicted 15-Day Value [95% CI]</th>
<th>Observed 15-Day Value</th>
</tr>
</thead>
<tbody>
<tr>
<td>Interval 3-Day: Subject 1</td>
<td>( \log e[2.12 + (-0.22)(\log e 9)^a +(-0.19)(\log e 14)^a +(0.89)(\log e 17)^a] )</td>
<td>38.7 [31.9, 48.4]</td>
<td>40</td>
</tr>
<tr>
<td>Consecutive 3-Day: Subject 2</td>
<td>( \log e[2.36 + (-0.06)(\log e 9)^a +(-0.06)(\log e 14)^a +(0.58)(\log e 17)^a] )</td>
<td>41.0 [31.3, 53.3]</td>
<td>37</td>
</tr>
</tbody>
</table>

* The three interval-day and consecutive day variety scores for Subject 1 and 2 were 9, 14, and 17.

The average for all 72 subjects of the predicted 15-day cumulative DVS from 3 interval days of data was 43.4. The average from 3 consecutive days was 42.5 as shown in Table 6. The mean bias was smaller for the random 3-day prediction of 15-day dietary variety than the consecutive 3-day dietary variety prediction, 0.12 vs. –0.77 respectively thus demonstrating the 3 interval-day method was more accurate. The correlation with the observed 15-day dietary variety score was higher for the 3 interval days than 3 consecutive days, 0.75 vs. 0.66 respectively, demonstrating the interval-day method provides a better fit for the data. Finally, the mean squared error for predicting the observed 15-day dietary variety score by the 3 interval day method was smaller than...
the 3 consecutive day method, 31.9 vs. 41.6 respectively, showing the interval method is more precise at predicting 15 day dietary variety for an individual. In other words, the 3 interval-days of dietary data collected over 15 total days has higher correlation and is more precise at the prediction of 15-day cumulative dietary variety than 3 consecutive days as predicted.

Table 6.

<table>
<thead>
<tr>
<th>Cumulative Dietary Variety Scores from 15 Consecutive Days, 3 Interval Days, and 3 Consecutive Days of Dietary Data for all Subjects (N=72). Predicted Values are Compared to Observed Values. a</th>
</tr>
</thead>
<tbody>
<tr>
<td>Observed 15-Day Cumulative Dietary Variety Score (N=72)</td>
</tr>
<tr>
<td>Mean [95%CI]</td>
</tr>
<tr>
<td>Mean Bias</td>
</tr>
<tr>
<td>Correlation</td>
</tr>
<tr>
<td>Mean Squared Error</td>
</tr>
</tbody>
</table>

a Predictions based on the equations shown in Table 4.A.

Validation

Comparison of the 4th grade data utilizing 5th grade equations to predict a 15-day dietary variety score was done. The reverse was done as well to validate the 5th grade data utilizing 4th grade equations.
Cross-Validation Results

Regression Coefficients of One Grade of Students are used to Predict 15-Day Cumulative Dietary Variety Scores of another Grade of Students. Predicted Values are Compared to Observed Values.

Table 7A.  
**Fifth Grade used to Predict Fourth Grade**

<table>
<thead>
<tr>
<th></th>
<th>Observed 15-Day Cumulative Dietary Variety Score (N=40)</th>
<th>Predicted 15-Day Cumulative Dietary Variety Score from 3 Interval Days (N=40)</th>
<th>Predicted 15-Day Cumulative Dietary Variety Score from 3 Consecutive Days (N=40)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Mean [95 % Confidence Interval]</td>
<td>41.2 [40.0, 42.3]</td>
<td>42.5 [41.7, 42.2]</td>
<td>42.3 [41.7, 42.9]</td>
</tr>
<tr>
<td>Mean Bias (Predicted-Observed)</td>
<td></td>
<td>1.3</td>
<td>1.1</td>
</tr>
<tr>
<td>Correlation (Predicted-Observed)</td>
<td></td>
<td>0.78</td>
<td>0.55</td>
</tr>
<tr>
<td>Mean Squared Error (Predicted)</td>
<td></td>
<td>31.4</td>
<td>51.4</td>
</tr>
</tbody>
</table>

Table 7B.  
**Fourth Grade used to Predict Fifth Grade**

<table>
<thead>
<tr>
<th></th>
<th>Observed 15-Day Cumulative Dietary Variety Score (N=32)</th>
<th>Predicted 15-Day Cumulative Dietary Variety Score from 3 Interval Days (N=32)</th>
<th>Predicted 15-Day Cumulative Dietary Variety Score from 3 Consecutive Days (N=32)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Mean [95% Confidence Interval]</td>
<td>46.0 [44.2, 47.7]</td>
<td>44.6 [43.6, 45.6]</td>
<td>43.8 [42.9, 44.8]</td>
</tr>
<tr>
<td>Mean Bias (Predicted-Observed)</td>
<td></td>
<td>-1.3</td>
<td>-2.2</td>
</tr>
<tr>
<td>Correlation (Predicted-Observed)</td>
<td></td>
<td>0.64</td>
<td>0.47</td>
</tr>
<tr>
<td>Mean Squared Error (Predicted)</td>
<td></td>
<td>40.0</td>
<td>58.0</td>
</tr>
</tbody>
</table>

The results for the cross-validation studies show the mean bias for the 5th grade coefficients predicting the 4th grade cumulative dietary variety score is smaller but not significantly so for the 3 consecutive day method, 1.1 vs. 1.3 respectively. Therefore, 3 consecutive days are slightly more accurate at predicting 15-day cumulative dietary variety score than 3 interval days. The opposite is true when 4th grade coefficients are used to predict 5th grade 15-day cumulative dietary variety score. 3 interval days have a
smaller mean bias than 3 consecutive days, -1.3 vs. –2.2 respectively. For both cross-validation methods 4th predicting 5th vise versa the 3 interval-day method has a higher correlation and smaller mean squared error than the 3 consecutive day method for predicting 15-day cumulative dietary variety score.

**DISCUSSION AND CONCLUSIONS**

This study examined the relationship between three interval-days of 24-hour dietary recalls, 3 consecutive days of 24-hour dietary recalls and 15 consecutive days of 24-hour dietary recalls. This study concluded that an overall dietary variety score could be obtained by multiplying the resultant 3-day variety score by the predictive equation coefficients and obtaining a 3-day variety score utilizing interval days was more accurate than consecutive days. However, a three day collection of dietary intake will not give an overall representation of particular types of foods eaten, only a score or number. On average, the number of different foods and beverages consumed obtained by the analysis of three random days was less than half the number of different foods and beverages obtained by the fifteen consecutive days. Therefore, the practicality of this method is low unless a researcher or professional was solely interested in a dietary variety score and not actual types of different foods or beverages consumed. If this is the goal, the study provides equations, which allow the estimation of a dietary variety score to be possible in the 4th and 5th grade population utilizing only three days of dietary data. The gold-standard method for dietary recall to obtain true variety of dietary intake remains fifteen consecutive days in this population.

As reported by Drewnoski et al. and Falciglia et al. (23, 34), dietary variety in this population leveled off after 15-days of dietary intake. The average amount of different foods and beverages consumed in this population over 15 days is 43. The observed
average of the amount of different foods and beverages consumed in the three interval
days chosen from 15 days was considerably less at 20. The number of foods was even
lower for the three consecutive days therefore, it could not be concluded from this study
that 3 days of dietary intake data captures dietary variety as well as 15 days of dietary
intake data. It was expected that the 3 days of dietary data would most likely not assess
variety as well as 15 days of dietary data but it would hopefully give a more adequate
estimate and overcome the issue of burden, enabling 3 days of dietary data to be more
practical for clinical and research use. However once predictive equations were applied
to the data from three days of dietary intake, a dietary variety score comparable to a 15-
day dietary variety score was obtained. It can be concluded from this study that the 3
random day method is validated for use in this population of 4th and 5th graders for
predicting a 15-day cumulative dietary variety score in individuals.

IMPLICATIONS FOR RESEARCH AND PRACTICE
As with any study, especially a novel one, the need for future research was identified.
This study cohort was not representative of all fourth and fifth grade classrooms and
students. Any results gained from this study may not be applied to the entire population
of elementary school students in grades 4 and 5; similar studies need to be conducted in
varying socioeconomic settings and with varying ethnicities to be more representative of
all fourth and fifth grade students. Because the research is being performed with
children, it is assumed that the conclusions drawn from this can be transferred to adult
populations, as they are typically better at estimating their dietary intake. Further
research would be needed though to confirm this. There were a large number of
students in each classroom and most of the time only one researcher was present while
the recalls were being completed. Better results may have been obtained if the children
were dealt with on a one on one basis with a researcher. Also, students had to complete five of the fifteen days while at home over the weekend. Many of the children forgot to complete the assignment or parents may have helped their child fill out the recalls thus introducing bias, and it was possible the weekend recalls differed from the daily recalls completed in school. Research in a more controlled setting may produce better results.

Past studies have concluded that fourth and fifth grade age students were able to accurately complete recalls and remember what they had eaten in the previous 24 hours. Researchers conducting the present study found this to be untrue for the majority of fourth graders in the study sample. Possible reasons include the lack of one on one interaction between the researcher and student and the short time allotment given to complete the recalls in the classroom. Fourth and fifth grade students may need additional time to accurately and completely recall their entire dietary intake from the previous day. Finally, since the students were at the beginning of the school year, the fourth graders although a year older than the previous year, only had a third grade education at this point. Similarly, the fifth graders may have been more representative of fourth grade education levels. It was evident to the researchers that many of the participating students became fatigued throughout the study. Recalls that were well completed in the beginning of the fifteen days began to decrease in completeness towards the end of the study and dropouts were noted. This was expected due to the age group and this was the basis for this study as an easier method of obtaining a child’s overall dietary was the goal. There were five different classrooms enrolled in the study, so completeness of the recalls and overall student participation could have been directly related to the enthusiasm and involvement of each individual teacher.

Despite any limitations, it was felt this was groundbreaking research, which offers an alternative method to easily obtain the number of different foods a particular individual
is eating in just 3 days of data collection. In the future, a definition of what constitutes “good”, “average” and “poor” dietary variety in terms of numbers of food will be necessary to increase the practicality of this method. Additionally, further research could help determine if there are better ways of capturing an individual’s dietary variety without statistical manipulation.
References


Appendix A
University of Cincinnati
Department of Nutritional Sciences
363A French East
202 Goodman Avenue
P.O. Box 670394
Cincinnati, OH 45267

August 2003

Dear Parent or Guardian:

We would like to invite your child to participate in a nutrition research study. This involves three main things. First your child will fill out a general information form. Then for fifteen days you child will write down what they eat and drink. Finally we will measure the children’s height and weight. There are no correct responses. Your child would do this project with the other children in the classroom. It will be done during the day at Weller Elementary School and over two weekends when they are not in school. Your child’s participation is voluntary. Their grade will not be affected in any way. This activity will take no longer than ten minutes a day.

Stacie Steele and Amy Reed are graduate students from the University of Cincinnati. We will be collecting the information for our thesis. Mrs. Steele and Mrs. Reed will give the forms to the students. Your child’s teacher will be in the room while your child and the other children complete the forms. The school principal has approved this study. Your child will not be identified by name. Giving each child a number will protect confidentiality. The children’s names will not be connected in any way to the data we collect from them.

If you give consent for your child to be part of this activity, please sign the enclosed Informed Consent Document. Please return the form on Tuesday, August 26, 2003. The first day of class is when the study is expected to start. Your child will not be able to participate without the permission form.

Thank you for your help. Please feel free to contact us with questions about this study. Stacie Steele: 513-321-1854, Stacie_horner@hotmail.com, or Amy Reed: 513-533-0230, AmyE.Reed@cchmc.org. If you would like the results for your child please email either of the researchers.

Sincerely,

Stacie L. Steele, BA  Amy E. Reed, BS, RD, LD
Researcher  Researcher
University of Cincinnati  
Consent to Participate in a Research Study  
College of Allied Health Sciences  
Stacie L. Steele  
Phone #: 513-321-1854  Email: Stacie_Horner@hotmail.com  
Amy E. Reed  
Phone #: 513-533-0230  Email: AmyE.Reed@cchmc.org

Titles of Studies:
1. The relationship of three 24-hour Food Recalls compared to fifteen 24-hour Food Recalls as a measure of dietary variety in school-aged children.
2. The relationship between dietary variety and body mass index in school-aged children.

Introduction:
Before agreeing to let your child be in this study, it is important to read and know the following. It states the purpose, procedures, risks, and benefits of the study. It also explains the right to quit the study at any time. It is important to understand that the results of the study cannot be guaranteed.

Purpose:
The purpose of this study is to see if three random 24-hour food recalls can be similar to fifteen 24-hour recalls. Also, the purpose is to see if there is a relation between variety of food and body mass index in children. Your child will be one of about 100 students taking part in this study.

Duration:
Your child will spend about 20 minutes a day for 15 days on this study.

Procedures:
During the course of this study, the following will occur:
8 A form asking general information will be filled out by the children
9 An assent form will be filled out by the children in the classroom so they understand what they are participating in
10 A brief 30-minute nutrition introduction using teaching how to measure and record the amount of food one is eating. The two researchers Amy and Stacie will do this.
11 Fifteen 24-hour recalls of what was eaten in the last day. In class each child will write what they ate the day before. On weekends, children will need to do the 24-hour recalls at home. The phone number of the principal investigators will be available for questions. Each recall should take no more than ten minutes to complete.
12 One investigator will collect the heights and weights of each child.

Exclusion:
Your child will not be able to take part in this study if any of the following apply to them:
1 If your child does not bring consent form on the first day of study
2 If your child must exclude a food group from their diet due to a health
problem

Risks/Discomforts:
There are no known risks associated with this study. The only discomfort may come from the children having their heights and weights taken.

Benefits:
You will receive no direct benefit from your child being in this study. Their input may help health care providers better understand how to measure people’s diets. This will help them better care for their patients. Parents will have the option of receiving a copy of the results for their child.

Alternatives:
A couple of options are available if you choose to not have your child in the study:
1. Take part in the activities without data being entered into the study.
2. If you choose to not have you child take part at all, they will be given other activities to do such as puzzles and word searches. These will not be graded.
School grades will not be affected if these options are chosen.

New Findings:
You will be told if there is any new information that becomes available during the study that may affect your willingness to continue participation in the study.

Confidentiality:
Every effort will be made to keep the confidentiality of the study records. Only certain staff of the University of Cincinnati will be allowed to look at parts of the records related to this study. The data from the study may be published; however, your child will not be identified by name. Numbers will be given to each child so their names are not linked to their data.

Payments to participants:
Your child will get small gifts such as pencils, stickers, etc. for being in this study. The gift schedule is:
1. Small gift with return of a complete recall the first day
2. Small gift after each weekend when complete recalls are returned (total of two weekends)
3. Small gift at the end of the study for doing all the recalls
Children who do not participate will not be left out from the gifts. The gifts are a token of thanks for your child’s time in the study.

Right to refuse or withdraw:
This study is voluntary. Your child may refuse to participate or may quit AT ANY TIME. There will be no penalty or effect on their school grade. The researcher has the right to take a child out of the study AT ANY TIME. Removal from the study may be due to the student (for example, not following study-related directions from the researcher, etc.) or because the entire study has been stopped.

Offer to answer questions:
If you have any other questions about this study, you may call Stacie Steele at 513-321-1854, Amy Reed at 513-533-0230, or Dr. Grace Falciglia at 513-558-7505. If you have any questions about your child’s rights as a participant, you may call Dr. Margaret Miller, Chair of the Institutional Review Board – Social and Behavioral Sciences, at 513-558-5784.

**LEGAL RIGHTS:**
Nothing in this consent form waives any legal right you may have nor does it release the investigator, the institution, or its agents from liability for negligence.

**I HAVE READ THE INFORMATION PROVIDED ABOVE. I VOLUNTARILY AGREE TO LET MY CHILD PARTICIPATE IN THIS STUDY. I WILL RECEIVE A COPY OF THIS CONSENT FORM FOR MY INFORMATION.**

Legal Representative/Parent

Signature_________________________________________

Date___________________________

________________________________________
Child/Student Name
Appendix B
ASSENT FORM

Project Title: The relationship of three random 24-hour Food Recalls compared to fifteen consecutive 24-hour Food Recalls as measures of dietary variety in school aged children

Investigators: Stacie L. Steele, BA, Master’s Research Student
Amy Reed, BS, RD, LD, Master’s Research Student
Person Obtaining Consent: Stacie L. Steele, BA

We are doing a research study. The research will help us learn more about something. We want to find out what foods and drinks you have each day.

If you decide you want to be in this study, we will ask you to do three things: 1. Do an activity to learn how to fill out a special form and measure food and drinks; 2. Write down what you eat for fifteen days; and 3. Get your height and weight taken.

There are no right or wrong things to write down. This will not affect your grade in any way. We just want to know what you have to eat and drink.

We hope to find out things that will help other kids some day.

When we are done with the study, we will write a report about what we found out. We won’t use your name in the report.

You don’t have to be in this study even if your parents want you to. It’s up to you. If you say okay now, but you want to stop later, that’s okay too. Your grade will not be affected. All you have to do is tell us.

If you want to be in this study, please sign your name.

I, ___________________________________, want to be in this research study.

(Print your name here)

______________________________
(Sign your name here)   ___________________
(Date)
Appendix C

GENERAL INFORMATION FORM

NAME_______________________________________________________

AGE__________________      GENDER (male or female)______________

Do you take a vitamin?     YES         NO        (Please circle one)
   If YES, what vitamin(s) do you take?__________________________
   How often do you take the vitamin(s)?_________________________

Do you not eat foods from one or more of the food groups?
   YES        NO         (Please circle one)
   If YES, what food group(s) do you not eat and why?__________________________

Please do not write below this line
-------------------------------------------------------------------------------------------------------------------

WEIGHT_________________________

HEIGHT_________________________

BMI_____________________________
## 24-Hour Dietary Intake Form

<table>
<thead>
<tr>
<th>Food Description and Brand Name</th>
<th>Source (Check one)</th>
<th>Time of Day</th>
<th>Amount Eaten</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Homemade</td>
<td>Restaurant</td>
<td>School</td>
</tr>
<tr>
<td>Ex. Granola Bar-Quaker Oatmeal Raisin</td>
<td>X</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

S. Steele and A. Reed 2003
Appendix E

24-hour recall protocol:

We would now like you write down everything you ate and drank yesterday. Please do not leave anything out and try to estimate the size as best as you can. If you have any questions you can ask us for assistance.

1. Everyone think about when you woke up yesterday, did you have anything to eat or drink?
2. After you woke up what did you do? Did you get ready for school or go somewhere? After this, did you eat or drink anything?
3. Anytime before lunchtime yesterday did you have a snack or a drink?
4. Did you eat at lunchtime yesterday? If so, think about everything you had to eat and drink.
5. In the afternoon did you have anything to eat maybe after school or when you got home from somewhere?
6. Did you eat dinner or supper yesterday? If so think about what time it was and what you had to eat and drink.
7. Did you eat or drink anything else the rest of the night? Maybe a dessert or a snack before bed. Please write them down.

Now look over everything you wrote down that you ate and drank yesterday. Did you miss anything? If so please write it down at this time. When you are finished you can hand your completed forms into me.