Team 3447

Lunch Crunch: Can nutritious be affordable and delicious?

Summary

We have been asked by the USDA to analyze the ramifications of Michelle Obama's initiative for better nutrition in schools, the Healthy, Hunger-Free Kids Act of 2010. With rising food prices and competing interests of students, school districts, and the government, a fiscal crisis is emerging for some schools. Rather than making students responsible for their own food, a program must be developed in order to meet the necessary nutritional requirements of students, since as many as half of total calories and two meals a day can be consumed from school food during the day, especially among low-income students.

Specifically, we develop a model to find the necessary caloric intake throughout the day to create accurate averages for different types of students, including variations in ethnicity, gender, and location relative to a large metropolitan area, taking into account weight, height, and age for each. Doing so requires finding the average growth for pre-pubescent males and females, and pubescent males and females. We then use the revised Harris-Benedict equation for Basal Metabolic Rate, which applies only without growth of the body or physical activity, and modify it to account for natural growth of children in various life stages. We take into account the average physical activity of each group of students. Since caloric intake is additive we add those two equations to each other to represent the total amount of calories that are required to sustain the current rate of growth and physical activity at each respective age. From this value, we can calculate what percentage of children's need are not met.

Next, we develop a distribution in order to estimate the percentage of students whose needs are being met. By combining some of the data from the first part and calculating standard deviation values from standard error values according to the CDC, we create a normal distribution to model elementary school, middle school, and high school male and female demographics of required calories per day. To find the amount required for lunch, we assume 40% of daily intake of calories come from lunch (mydailyintake). From this calculation, we find that only about 17% of all students' need are in fact not being met; however, as an important disclaimer, high school males represent a massive proportion of this unsatisfied population in our model.

Third, we create a lunch plan to satisfy the three competing interests. We compare bulk prices of food and convert values to costs per student per week and the cost the school can afford in order to develop a sample school menu based on the serving requirements of the initiative and attempt to fit the caloric intake to the values specifically mandated by the initiative. Because of difficulty in finding appropriate foods to fit a school lunch, we had to modify our menus many times, eventually finding a model that would suffice, along with a minimal one in which the schools can keep more profit.

Finally, we analyze how these results hold under various conditions by justifying our assumptions and providing a general overview of how this can be applied to the national scale under various geographic and socio-economic conditions throughout the country. We find that since, on most averages, urban, lower income schools have a lower daily need, the initiative would more easily be adopted in lower-income schools, where it would help schools save money

without sacrificing students' caloric needs.. This requirement would seem to satisfy its initial goals of giving better nutrition to populations which would otherwise not have access to healthier lunch options.

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Acronyms	Meaning
BMR	Basal Metabolic Rate
PA	Physical Activity
kcal	Kilocalories
CN	Calories Needed for Physical Activity
LM	Recommended caloric intake for one male student's lunch
LF	Recommended caloric intake of one female student's lunch
DN	Daily Caloric Needs
P	Caloric needs at rest, without growth constants

Introduction and Background

School lunches have always been a topic of debate for students. School lunches have been notorious for being dissatisfying to students, but to what extent? Analyzing this problem falls into three areas of preference. Students care about taste and quantity, schools care about affordability, and the government cares about promoting healthy lifelong eating habits to set the tone for the eating habits of the next generation of the population to live longer, healthier lives.

Since the implementation of the Healthy, Hunger-Free Kids Act of 2010, healthy lunch options have been expanded, but has the appropriate amount of calories been added as well?

Students may wish to consume more unhealthy options, but school districts must ensure students have sufficient energy and nutrition to carry them throughout the day while taking into account the financial needs of the school.

Additionally, school districts have been increasingly pressed to provide these healthier food options, but doing so requires more effort preparing foods on-site as opposed to prepackaged food, which tend to be unhealthier food, as well as costs associated with buying healthier, fresher food.

Restatement of Problem

We have been asked by the USDA to analyze the caloric intake necessary for students in school, find the percentage of students whose caloric needs are being met based on President Obama's Healthy, Hunger-Free Kids Act of 2010, and develop a lunch plan given an average of $7 funding per student per week and the effects of a reduction of $1 from this initial amount.

General Assumptions

- ❏ Students' needs are reset each morning, allowing average value to be applied over various time periods.
- ❏ Student's activities can be generalized to create accurate models for the actual mean exercise levels and required caloric intakes

Introductions

School lunches have always been a topic of concern for students and administrators alike. With the introduction of Michelle Obama's initiative for healthy eating, there are questions as to whether students are receiving sufficient nutrition for each meal.

Caloric Needs of Students

In order to properly asses the necessary amount of calories that school lunches should contain, we herein develop a model to accurately calculate the caloric needs of students.

Assumptions:

1. Puberty numbers are average because growth spurts vary based on genetics and are impossible to predict
2. Pre-pubescent boys' and girls' growth is roughly the same after 4y of age (Rogol et al.)
3. Average daily caloric composition is difficult to quantify based upon diets, cultural customs, and income; values of 55% carbohydrates, 30% fats, and 15% protein per kcal of intake were determined; despite 30% fat being unhealthy, the average American diet contains 20-35% of calories from fat and children are less likely to be dieting, leading them to be towards the higher end of the fat spectrum (mydailyintake).
4. Assume the amount of daily caloric intake is 100%, 40% of which is lunch, because students do not have time periods built in for "Mid-Morning Snack" or "Afternoon Snack;" a student's lunch must take into account the absence of snacking periods

(mydailyintake).

5. We assume that all the energy of foods consumed are completely absorbed and converted to weight gain and not expelled through feces or gases such as carbon compounds.
6. Grade school is 6 years old-11 years old, middle school is 11 years old-12 year olds, and high school is 14-18 years old.

The most often used model for BMR, or Basal Metabolic Rate, is the Harris-Benedict Equation. The equation was derived in 1918-1919, but was revised for more modern factors in 1984 by Roza and Shizgal; this equation, however, only accounts for the needs of the body at rest in order to maintain a constant body mass, of which students certainly are not, as they are growing and participate in physical activity. Ergo, further modifications must be made in order for the daily caloric intake of students to be determined.

Revised Harris-Benedict Equation (Roza and Shizgal)

Women:

$$P = \left(\frac{9.247m}{1\ \text{kg}} + \frac{3.098h}{1\ \text{cm}} - \frac{4.330a}{1\ \text{year}} + 447.593\right)\frac{\text{kcal}}{\text{day}}$$

Men:

$$P = \left(\frac{13.397m}{1\ \text{kg}} + \frac{4.799h}{1\ \text{cm}} - \frac{5.677a}{1\ \text{year}} + 88.362\right)\frac{\text{kcal}}{\text{day}}$$

Where m=mass (kg) h=height (cm) and a=age (years)

Until the ages of eleven and thirteen for girls and boys, respectively, the average increase in mass is 2.5 kilograms per year; after the onset of puberty, the average increase in female mass is 8.3 kilograms per year, and the average increase in male mass is 9 kilograms per year (Rogol et al.). The number of calories consumed to add this body mass is necessary to a student's daily caloric needs. We must assume that all extra calories will be converted to body mass through growth and not lost through feces or respiration in order to calculate these minimum needs in addition to the BMR Revised Harris-Benedict Equation. Carbohydrates and proteins provide 17 kJ per gram consumed, and fats provide 37 kJ per gram consumed. According to the assumed American diet consisting of 55% of calories from carbohydrates, 30% of calories from energy-dense fats, and 15% of calories from proteins, the mass of food per hundred kilojoules of energy is 4.92846 grams. To add one kilogram of weight, an individual must consume 20,290.3 kJ of the typical American diet, or 4,849.50 kcal.

Coupled with the growth rates of prepubescent children, pubescent boys, and pubescent girls, the constants have been determined for the average amount of additional calories needed to indemnify the amount of energy required to grow during prepubescent and pubescent periods: 33.22, 110.28, and 119.58 kilocalories per day for prepubescent children, pubescent females, and pubescent males, respectively, which was calculated:

$$\frac{2.5\ kg}{year} * \frac{4849.5\ kcal}{kg} * \frac{1\ year}{365\ days} = 33.22\ \frac{kcal}{day}$$

$$\frac{8.3\ kg}{year} * \frac{4849.5\ kcal}{kg} * \frac{1\ year}{365\ days} = 110.28\ \frac{kcal}{day}$$

$$\frac{9.0\ kg}{year} * \frac{4849.5\ kcal}{kg} * \frac{1\ year}{365\ days} = 119.58\ \frac{kcal}{day}$$

Therefore, we add these growth constants to our revised Harris-Benedict Equation to find the total BMR of growing children,

$$BMR_{ppf} = \left(\frac{9.247m}{1\ kg} + \frac{3.098h}{1\ cm} - \frac{4.330a}{1\ yr} + 447.593\right)\frac{kcal}{day} + 32.22\frac{kcal}{day}$$

$$BMR_{f} = \left(\frac{9.247m}{1\ kg} + \frac{3.098h}{1\ cm} - \frac{4.330a}{1\ yr} + 447.593\right)\frac{kcal}{day} + 110.28\frac{kcal}{day}$$

$$BMR_{ppf} = \left(\frac{13.397m}{1\ kg} + \frac{4.799h}{1\ cm} - \frac{5.667a}{1\ yr} + 88.362\right)\frac{kcal}{day} + 32.22\frac{kcal}{day}$$

$$BMR_{ppf} = \left(\frac{13.397m}{1\ kg} + \frac{4.799h}{1\ cm} - \frac{5.667a}{1\ yr} + 88.362\right)\frac{kcal}{day}119.58\frac{kcal}{day}$$

Where BMR_{ppf} is the BMR of a prepubescent female, BMR_f is the BMR of a pubescent female, BMR_{ppm} is the BMR of a prepubescent male, and BMR_m is the BMR of a pubescent male. The domain restrictions of the female functions are 4-11 years of age for the prepubescent female modified equation and 12-21 years of age for the pubescent female modified equation, 4-13 years of age for the prepubescent male equation and 14-21 for the pubescent male equation. This is due to the average age of entry to puberty being eleven for females and thirteen for males (Rogol et al.).

However, most students do not live sedentary lifestyles and therefore compensation to the BMR equation is in order. As calorie consumption is additive, we add our equation for caloric usage during physical activity,

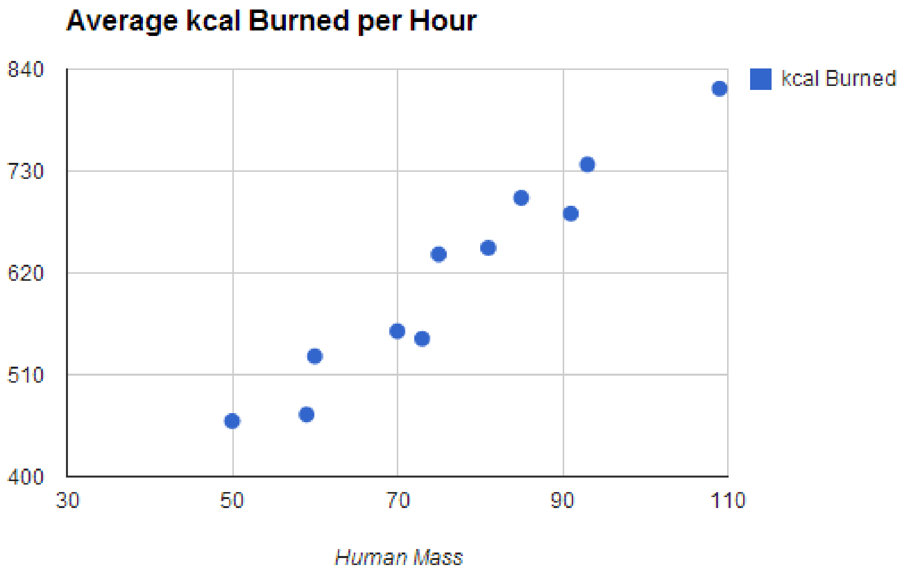
$$CN_{PA} = \left(\frac{6.464m}{1\ kg} + 120.22\right)\frac{t * kcal}{1\ hr * day}$$

to our adjusted BMR equations, where, again, m = the mass of the student in kilograms and t = the student's time spent in vigorous physical activity in hours. We arrive at this equation by collecting information from three different sources on kcal burned per hour for different activities of people with different masses, like the Mayo Clinic, partially pictured here:

Activity (1-hour duration)	73 kilograms	91 kilograms	109 kilograms
Aerobics, high impact	533 kcal	664 kcal	796 kcal
Aerobics, low impact	365 kcal	455 kcal	545 kcal
Aerobics, water	402 kcal	501 kcal	600 kcal
Backpacking	511 kcal	637 kcal	763 kcal
Basketball game	584 kcal	728 kcal	872 kcal

In order to find kcal burned per hour for each variable mass, we took the average kcal burned per hour of several consistent mid-to-high intensity activities (running, basketball, tennis, cycling, and calisthenics) from their respective sites to find the average energy burn per hour of strenuous exercise for each mass, since energy burn will be variable dependent on mass (Mayo, Nutristrategy, Shape Up).

When energy burn per hour is plotted versus mass:



we can use regression to develop the equation above, with $r^2 = 0.94$. The equation relates the mass and energy so that by plugging in the known value (mass) we can determine energy burned per hour and, by multiplying by time spent in exercise, total energy in need of replenishment.

Once all of the modifications have been completed, the equation determines more accurately the daily caloric intake of students from ages 4-21 taking into account the attributes/variables of m (mass in kilograms), h (height in centimeters), a (age in years), t (hours spent in vigorous physical activity), DN_F (daily needs for a female student), and DN_M (daily needs for a male student).

$$DN_F = \left(\frac{9.247m}{1\ kg} + \frac{3.098h}{1\ cm} - \frac{4.330a}{1\ year} + 447.593\right)\frac{kcal}{day} + 33.22\frac{kcal}{day} + \left(\frac{6.464m}{1\ kg} + 120.22\right)\frac{t * kcal}{1\ hr * day}$$

(When a<11)

$$DN_F = \left(\frac{9.247m}{1\ kg} + \frac{3.098h}{1\ cm} - \frac{4.330a}{1\ year} + 447.593\right)\frac{kcal}{day} + 110.28\frac{kcal}{day} + \left(\frac{6.464m}{1\ kg} + 120.22\right)\frac{t * kcal}{1\ hr * day}$$

(When a>11)

$$DN_M = \left(\frac{13.397m}{1\ kg} + \frac{4.799h}{1\ cm} - \frac{5.667a}{1\ year} + 88.362\right)\frac{kcal}{day} + 33.22\frac{kcal}{day} + \left(\frac{6.464m}{1\ kg} + 120.22\right)\frac{t * kcal}{1\ hr * day}$$

(When a<13)

$$DN_M = \left(\frac{13.397m}{1\ kg} + \frac{4.799h}{1\ cm} - \frac{5.667a}{1\ year} + 88.362\right)\frac{kcal}{day} + 119.58\frac{kcal}{day} + \left(\frac{6.464m}{1\ kg} + 120.22\right)\frac{t * kcal}{1\ hr * day}$$

(When a>13)

This equation, however, determines the amount of kcal (Calories) necessary for a day, while lunch consists of a lesser portion of the daily consumption. According to mydailyintake.net, the amount of daily caloric intake that lunch consists of is 20%; the model also includes a mid-morning snack and an afternoon snack, which are not available in the rigorous schedule of today's American schools, so those 10% values are included in the lunch caloric intake. The daily caloric needs are then multiplied by .40 to find the kcal needed in a school lunch. The final equations become:

$$LF = .4 * \left(\left(\frac{9.247m}{1\ kg} + \frac{3.098h}{1\ cm} - \frac{4.330a}{1\ year} + 447.593\right)\frac{kcal}{day} + 33.22\frac{kcal}{day} + \left(\frac{6.464m}{1\ kg} + 120.22\right)\frac{t * kcal}{1\ hr * day}\right)$$

(When a<11)

$$LF = .4 * \left(\left(\frac{9.247m}{1\ kg} + \frac{3.098h}{1\ cm} - \frac{4.330a}{1\ year} + 447.593\right)\frac{kcal}{day} + 110.28\frac{kcal}{day} + \left(\frac{6.464m}{1\ kg} + 120.22\right)\frac{t * kcal}{1\ hr * day}\right)$$

(When a>11)

$$LM = .4 * \left(\left(\frac{13.397m}{1\ kg} + \frac{4.799h}{1\ cm} - \frac{5.667a}{1\ year} + 88.362\right)\frac{kcal}{day} + 33.22\frac{kcal}{day} + \left(\frac{6.464m}{1\ kg} + 120.22\right)\frac{t * kcal}{1\ hr * day}\right)$$

(When a<13)

$$LM = .4 * \left(\left(\frac{13.397m}{1\ kg} + \frac{4.799h}{1\ cm} - \frac{5.667a}{1\ year} + 88.362\right)\frac{kcal}{day} + 119.58\frac{kcal}{day} + \left(\frac{6.464m}{1\ kg} + 120.22\right)\frac{t * kcal}{1\ hr * day}\right)$$

(When a>13)

Percentage of Caloric Needs Being Met

To calculate how well the one-size-fits-provision meets the need of students, we compare the average required by students in each group to the allowed maximum calories allowed by each group.

Additional Assumptions

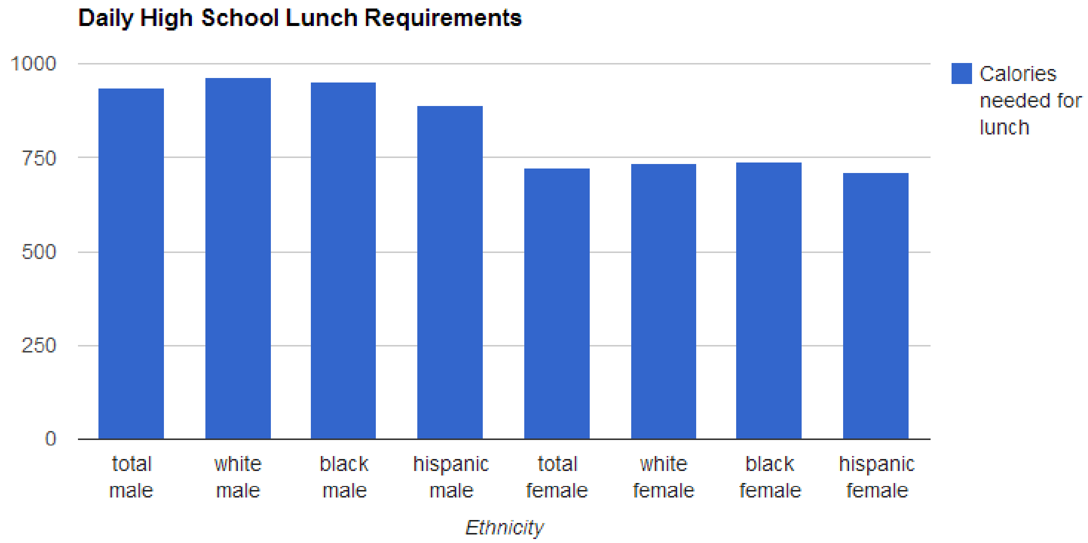
1. We can generalize the data across different ethnicities to generate a viable number for actual mean amount of calories per grade group.
2. Elementary school consists of 6 to 11 year olds, middle school consists of 11 to 14 year-olds, and high school consists of 14-18 year olds.
3. The average high school student is 16 years of age, the average middle school student is 12 years of age, and the average elementary student is 8.5 years of age

To determine which students' nutritional needs are not being met by the Healthy, Hunger-Free Kids Act of 2010, we found standard data for activity, weight, and height for select age points; we then inserted these variables into our equation for part 1 to determine the caloric needs for students of various demographics and for the average male student and female student in elementary, middle, and high school. For high school, we chose to break the data down by ethnicity; for elementary school, we chose to break the data down by location of the school:

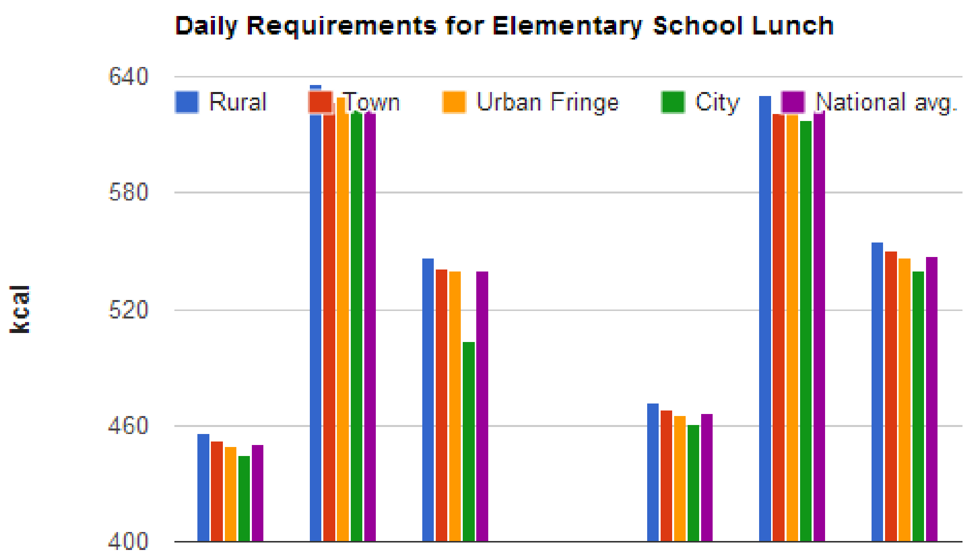
rural, town, urban fringe, and city. Only slight changes showed between ethnicities in high school students, as evidenced by the data tables and graph below (CNC):

High School Students	Very Active (1 hour per day)	Active (5/7th of an hour per day)	Inactive	Average Activity (hours)	kcal Added Due to Activity
Total male	28.3753	52.1739	19.4508	.656424 hours	394.6038
White Male	29.6214	52.6726	17.706	.672447 hours	414.668
Black Male	27.6331	49.0374	23.3296	.626598 hours	385.18
Hispanic Male	26.0705	52.0151	21.9144	.632241 hours	361.676
Total Female	16.5217	40.1449	43.3333	.4520 hours	238.4083
White Female	17.945	45.2967	36.7583	.502998 hours	256.5286
Black Female	13.245	29.0066	57.7483	.339640 hours	190.78
Hispanic Female	15.9332	37.7845	46.2822	.429222 hours	218.9

High School Students	Average Age	Average Height	Average Weight	BMR (Adjusted for growth)	Total Daily Caloric Needs (kcal)	Calories Needed for Lunch
Average Male	16	175.3	74.4	1951.77	2346.3738	938.54952
White Male	16	178.2	76.8	1997.78	2412.45	964.98
Black Male	16	177.8	76.5	1991.85	2377.03	950.812
Hispanic Male	16	169.7	69.9	1864.72	2226.396	890.5584
Average Female	16	161.9	63	1572.72	1811.1283	724.45132
White Female	16	164.1	60.3	1582.85	1839.3786	735.75144
Black Female	16	164	68.3	1656.51	1847.29	738.916
Hispanic Female	16	158.1	60.3	1564.26	1783.16	713.264



The differences in the activity of elementary school students increased in allotted recess and physical education class time for moderate to vigorous physical activity the farther the school was located from a major municipal area since we assume the city populations tend to exercise less than country populations (e.g. city, urban fringe, town, rural) (National Center for Education Statistics). We then calculated the caloric needs for lunch for each region and the national average using the final equations from part 1:



6 Years (Male-Female), 11 Years (Male-Female), Elementary Average (Male-Female)

This data allows us to discover the percentage of students whose needs are being met by the number of kilocalories per month allotted by the act, and to later discuss the effect of our model for calories needed on various demographics and geographic groupings.

According to the Healthy, Hunger-Free Kids Act of 2010, the average number of kilocalories allowed per lunch is 600 for elementary school students, 750 for middle school students, and 850 for high school students (Kuhn). We find a standard deviation for the distributions of these overall caloric intake requirements by adding together the variances of each by the equation

$$\sigma_{caloric\ intake} = \sqrt{2\sigma_m^2 + \sigma_h^2 + \sigma_a^2},$$

making sure to add standard deviation of mass twice because it is added twice in the equations of LM and LF. We then derive the values of sigma from the following data table by solving for standard deviation from the standard error given sample size (CDC) by rearranging the equation for standard error (with n being the number in the sample), since standard deviation of such a sample is an unbiased estimator of the population standard deviation:

$$SE = \frac{S_x}{\sqrt{n}} \quad into \quad S_x = (SE) * \sqrt{n}$$

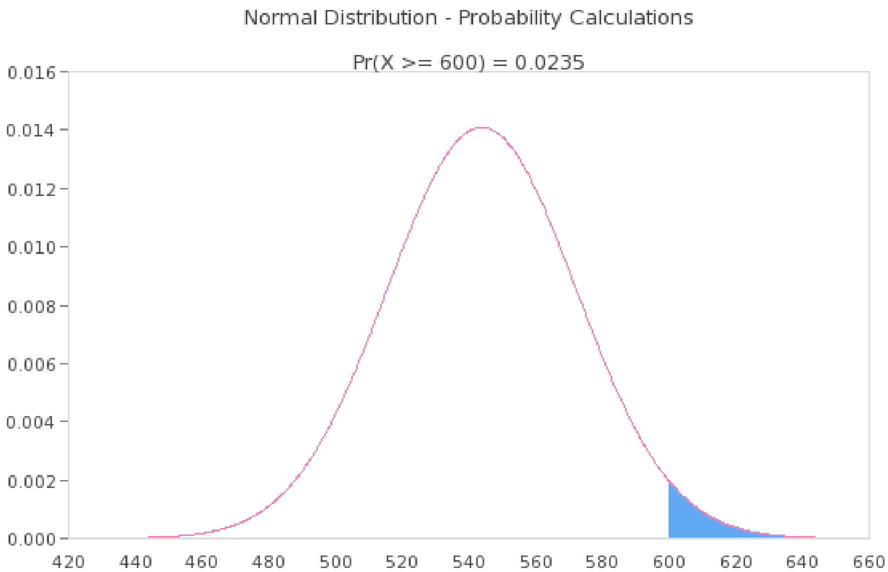
$$and \quad S_x \approx \sigma$$

The standard deviation for age is calculated with the ages from each of the three schools, with elementary school ages varying from 6 to 11, middle school from 11 to 14, and high school from 14 to 18. The

We then derive what percentage of students receive enough calories by performing a normal distribution with the appropriate means and standard deviations of each population with the z-score being set by the maximum available caloric intake during lunch.

Grade Level	Mass Standard Deviation, σ_m	Height Standard Deviation σ_h	Age Standard Deviation σ_a	Caloric Standard Deviation, σ
Elementary School	18.4823	10.708	1.8708	28.3082
Middle School	22.47	12.144	1.11	34.0306
High School, Male	19.8273	8.2916	1.8708	29.2952
High School,Female	24.49	10.564	1.8708	36.2577
	Mean kilocalorie/student, μ	Allowed Calories for Lunch	Percentage Caloric Intake not being Met	Total Weighted Average of All Students
Elementary School	543.7772	600	2.3511	

Middle School	649.875	750	0.1629	
High School, Male	938.5495	850	99.8747	
High School, Female	724.4451	850	0.0267	17.6706



A normal distribution of the elementary school statistics as produced by mathcracker

Averaging these values with weights of .3 for elementary school students, .3 for middle school, and .4 for high school students, we find an overall value of 17.6706% of students whose caloric needs are not being met, with a grossly high percent of male's needs not being met

Developing a Lunch Program

Given a budget of $7 per week per student and the data given by the resources in the USDA Foods Available List, we develop a school lunch program conforming to the recommended amounts of each of the food groups according to the FRDC Standard for Menu Planning and to allow a reasonable amount of calories as we had previously determined.

Accordingly, we develop a meal plan based on bulk amounts purchasable foods, cost of food, expiration date of food, and needs of students.

For our meal based upon a 7 dollar a week budget we choose the meal to be a combination of lean finely textured beef, whole grain rice, skim milk, and applesauce. So, to determine how much of each component to use, we set the 7 dollars a week that we have to spend equal to the caloric requirements of a highschool student, 5 days times 850 calories each student has per week (5 days times 850 school lunch calories a day). We found the maximum number of dollars per calorie to be 0.0016475. According to Farm Futures, the price of lean finely textured beef can be seen at 5 cents per pound. The Webstaraunt Store says that the price of applesauce is currently $3.49 per 99 oz can. At the same time one can see on Amazon that the price of long grain brown rice is $55.99/ 50 lbs. According to Understanding Dairy Markets, the average price of milk from the whole year based upon 1 month intervals is $3.462/ gallon of milk. Based upon these prices, we can derive the following equation:

$$\frac{Cost}{Student} = 850cal * 5days * \left(\frac{\$.00561}{cal} * P_a + \frac{\$.5599170}{cal} * P_r + \frac{\$.05110}{cal} * P_b + \frac{\$.216103}{cal} * P_m\right)$$

Where P_a , P_r , P_b , and P_m are the percent total calories of applesauce, rice, beef, and milk, respectively.

Multiplying by 850 and 5 determines the cost of the total cost of lunch per student per school week. Each of the coefficients attached to the different prices per calorie represent the percentage of that food that make up each students' lunch. The percentages were determined by trial and error.

$$\frac{Cost}{Student} = 850cal * 5days * \left(\frac{\$.00561}{cal} * .0588 + \frac{\$.5599170}{cal} * .0912 + \frac{\$.05110}{cal} * .55 + \frac{\$.216103}{cal} * .30\right)$$

$$\frac{Cost}{Student} = \frac{\$6.41}{Week}$$

The cost based on our given percentages was $6.41 per student per week,so our program meets the requirements of both the caloric intake of the average high school student, as well as the financial needs of the school budget of 7 dollars per week.

If we were to have our budget maximum decreased by $1 to a total of $6, we would have to increase the percent of the cheaper foods (such as the lean finely textured beef and the milk) comparative to the total amount of calories consumed; at the same time we would have to decrease the percentage of more expensive foods, such as applesauce and rice. Another option would be that we could decrease the total amount of calories required. That is a viable option for all populations other than the high school male, as 99.87% of them are not having their caloric need met, making them the major loser in any spending cut.

Extending to the National Scale

With our model, an effective lunch can be applied to various ethnic and socioeconomic backgrounds with ease. The largest factor in providing a relatively healthy lunch meeting the caloric needs of students is the amount of kcal needed by high school males. The current federal limit of 850 kcal per high school lunch cannot serve the needs of 99.87% of high school males; all other age and gender groups are adequately covered by the act's kcal limits. Our model can be used to find the minimum cost of a school lunch that encompasses all fruit, grain, meat, and dairy requirements for a meal, and can be adjusted to account for the kcal amount needed to satisfy any percentage of high school males. The equation to find the cost of a lunch with these requirements met is found by the equation:[1]

$$C_w = LM * 0.0075439 \frac{dollars * lunch}{kcal * school\ week}$$

Inserting the LM for a high school male of typical attributes (16 years of age, .656424 hours of physical activity per day, a weight of 74.4 kilograms, and a height of 175.3 centimeters) would determine the cost of a lunch to meet the nutritional requirements of 50% of high school males. This cost is $7.08, only 10% more. However, in order to meet the requirements of 95% of high school males, the LM would be 986.7358kcal/day which yields $7.44 cost per student per week, only 16% more expense to schools. However, if all males were physically active, (yielding a LM of 1022.57 with average height, age, and weight) the cost of the cheapest school lunch would be $7.72. To solve for alternative values of the population of male students being satisfied, one would solve the normal distribution probability where C_{Max} would be the maximum caloric intake necessary to satisfy Ξ% of males and NormInv is the normal inverse cumulative distribution function:

$$C_{Max} = 29.2952 * NormInv(.\Xi) + 938.5495$$

Our model can also be adjusted for a more specific ethnic group. One would simply plug in average height, weight, age, and physical activity level of males of that particular ethnic group into the LM equation and plug the answer into the cost equation. Plugging in the average values for African Americans shows the weekly per person budget necessary to properly feed half of African American males would be $7.17. We also conclude that conversion to this initiative will be easier within these minority socioeconomic conditions since in urban areas, the need is more easily met because the city population tends to not acquire as much exercise, and tend to be a higher percentage minority than the country population.

Limitations

Our model specifically analyzes the caloric intake needs of students in grades 1-12, however it does not take into account other nutritional requirements such as vitamin and mineral content. When adjusting the values for While our data does in fact account for the different age, race, and sex of students, it does not take into account all factors. According to our calculations 99.98% of high school males are underfed; this conclusion seems quite high, but it not out of the

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[1] C_W was determined by plugging LM, the kcal required for a male's lunch, into the cost per student equation after it had been solved for one variable (cost of a student's lunch per kilocalories per school week, removing 850 kcal for the variable LM.

question.es that are being properly fed by a significant amount. This is a significant limitation of the 7 dollar a week budget.

Results

The equation that we came up with in the part one of the question took into account many different parameters. Some of those parameters the Harris-Benedict equation did not take into account. The main difference was the growth of school children that is not taken into consideration within the Harris-Benedict equation as it is only valid for people ranging from ages 20-80. Because the majority of people in that interval are not growing we assumed that we would need to account for the calories that are needed to sustain a healthy growth rate.

After finding the adjusted BMR, we performed statistical analysis on the data by combining some of the ethnic and gender data when calculating a normal distribution to simplify calculations, however, we still used the distinction in gender data in high school students, and ethnic data when extending our results to the national scale. We find that for most age groups, the needs are easily met; per contra for high school males, we find that the caloric intakes fall short by about 100 calories and meet the needs of only about .1% of high school males.

To first go about finding an acceptable food budget for seven dollars or less we first searched for bulk prices of each food we had decided upon. After finding these prices we then converted each into the number of dollars per calorie. After finding the sum of all the cost per calorie, we assigned percentages to each source of nutrition. To find the total amount cost per week spent on lunches we multiplied the number found above by 850 calories and five days in one week, coming up with a total of $6.41 per week per student.

Conclusion

We find that, according to our model and assumptions, proper caloric intake can be accurately calculated to find necessary amount of calories needed per student per day taking into account a student's individual attributes. Applying these values to the allowed maximum caloric intakes under President Obama's Healthy, Hunger-Free Kids Act of 2010 we can evaluate the amounts necessary for each particular school.

When creating a school menu, the allocation of the prices that were necessary to construct our model for a $7 budget were especially difficult to obtain. The construction of the model after finding the prices of the food we chose became relatively easy. We conclude that by increasing the calories for males by only about 100 calories does not significantly challenge the budget requirements, in fact by as little as 11%. In fact, properly feeding 95% of high school males would only cost about a dollar per student more.

This initiative will fit many student's needs as well caloric intake requirements and likely other nutritional requirements as well. Most groups would in fact be satisfied under the Healthy, Hunger-Free Kids Act of 2010, but many high school males may stay unnecessarily hungry.

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