A Review of Food Diary Applications for Use in a Clinical Setting

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Thesis submitted for the degree of MS in Nutrition

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December 13, 2012

Abstract:

Background: A food diary is one of the best ways for a clinician to collect information about a patient's diet and nutrient intake. Previous studies have determined that an electronic method of collecting food information is as accurate and versatile as traditional pen and paper formats. With the introduction of new technologies, programs are being developed for people to use to keep their own electronic food diaries. In order to capture a niche in the health market developers strive to present unique food diary applications. This can lead to information overload when trying to select the proper application. In addition, not all applications may be useful in a clinical setting.

Objective: To evaluate seven of the most popular food diary applications and determine their usefulness in a clinical setting.

Method: A search was performed on the Apple App market using the phrase food diary. The seven most popular food diary applications (apps) were chosen and evaluated based on eight different categories. Each app was rated on a scale of 1 to 5 in each category and then an overall rating for the app was determined.

Conclusions: It was determined that the app My Fitness Pal would be most suitable in a clinical setting. It achieved the highest overall rating (4.1) out of the seven apps reviewed. Its strongest point was the amount of information provided in the food analysis with 16 nutrients examined.

Key Words: food diary, food analysis electronic data entry, iPhone, mobile phone

Introduction:

Today's health care landscape is undergoing significant changes from where it was twenty-five years ago. More emphasis is placed on diet and overall nutrition in the etiology of chronic disease. Preventative measures are being examined to see if they can impact disease. Physicians are looking at the body as an interconnected unit, not segmented parts with segmented conditions. As a result of these changes, whole health is being looked at instead of condition treatment. A significant portion of the whole health paradigm is nutrition. There are many conditions/diseases that can be addressed with nutrition and other lifestyle modifications. Examples include diabetes, heart disease, and celiac disease. Many conditions have a nutrition component that should be examined when deciding on the best course of treatment.

Nutrition is at the forefront of health related news with topics like organic food, food allergies, and obesity the subject of national conversations. Approximately two-thirds of US adults are overweight or obese and diseases that have links to obesity have jumped into the leading causes of death. (Ershow, Peterson, Riley, Rizzo, & Wansink, 2011) According to a recent study, obesity can be linked to sugar-sweetened beverages and poor dietary choices. (Collison, Zaidi, Subhani, Al-Rubeaan, Shoukri, & Al-Mohanna, 2010) In order to address the growing health needs of the population, physicians must address the growing problems of poor dietary choices and nutritional intake.

However, primary care physicians face two big obstacles. The first is a perceived lack of knowledge about nutrition and nutritional support. In one research study that surveyed practicing internists and current internist interns, 94% agreed that it was their obligation to

discuss nutrition with patients and 92% believed that it was their job to offer advice and counseling on nutrition. Contrast that with the finding that 86% believed that they were not trained to discuss nutritional issues with patients. (Vetter, Herring, Sood, Shah, & Kalet, 2008) These statements, taken together, lead to the conclusion that although internists believe that nutrition is an important portion of patient care, they do not feel qualified to address nutrition concerns. This issue, although very important, will not be examined in this paper. It is more appropriately tackled by the universities and continuing education programs. The other obstacle for primary care physicians is the gathering of nutrition information.

Primary care physicians are at the front of most nutrition battles because they see patients on a more regular basis. They are suited to monitor their nutritional heath and provide recommendations for beneficial changes that can have a huge impact on the overall health state of their patients. In order to address the nutritional status and gather the needed information, physicians use a variety of different tools. The most commonly used tools are a 24 hour recall, food frequency questionnaire (FFQ), and a daily food journal.

The 24 hour recall "traditionally requires administration by trained professionals." (Stumbo, et al., 2010) It involves the trained professional interviewing a patient on what they had to eat in the previous 24 hours. It requires a professional to question the patient in such a way to prompt their memory to remember what they have consumed, but not lead them to state erroneous information. Even with questioning by a professional, there are potential issues with patients being able to recall everything that they consumed in the previous 24 hours. That being said, Stumbo, et al. (2010) state that multiple 24 hour food recalls done over the course of several days "allow for a full description of dietary differences." However, these

are expensive to perform because of the neccessity of the trained professional and also the amount of time that must be invested in order to gain the complete nutritional picture. Therefore, they are often too costly and thus impractical for large scale studies.

The food frequency questionnaire (FFQ) is often the tool of choice for many practioners and for researchers conducting large studies or clinical trials. It involves having the patient fill out a questionnaire about how often they consume certain foods. One of the strengths of the FFQ according to Stumbo, et al. (2010) is that it captures the usual long-term food intake. This strength, coupled with its low cost, small time committment, and ease of distribution make the FFQ the method of choice. This method also has its drawbacks though. It gives a good overall picture of what the patient is consuming, but it is not all-inclusive. It covers a wide period of time and thus there is a real possibility for some food to slip through the cracks.

The final tool often used in primary care offices is the food diary. Patients keep track of their food and beverage intake daily for a variable length of time. Often, the food diary is done for a week or more in order to get an accurate picture of the patient's diet. Beasley, Riley, Davis, & Singh (2008) state that “When completed during or immediately after a meal, food diaries minimize memory recall errors.” One of the biggest difficulties with this method is patient compliance. This method requires patients to keep careful track of their intake day by day and accurately estimate portion sizes. This method suffers from both under and over reporting of food eaten. It also suffers from a low adherence to the complete protocol commitmment. Patients have traditionally shown a reluctance to write down their meals while out and about away from their home. This leads to patiets trying to complete their food diary from memory at a later date. Portion size estimation can be difficult to do when the conditions

are ideal (reference object, food is present while estimating, etc). Extra variance and bias is introduced when that task is being performed relying only on memory. However, despite these limitations and potential bias areas, when done corrrectly, the food diary is the best way to get a comprehensive overview of the patient's nutrition status.

After comparing these three methods, in the opinion of author, the one that gives the practioner the best set of information about the patient's nutrition is the food diary. However, the problems assoociated with the food diary may cause inaccurate results some of the time, causing many physicains to discount their effectiveness. Instead, they often prefer to use the 24 hour food recall or the FFQ. The inadequacies of the food diary can be addressed in two different ways. First, taking portion estimation out of the patient's hands. This would address the under and over estimation of the volume of food consumed. There are currently projects under way to address that area of the food diary. These projects will be reported on in the discussion section of this paper.

The second inadequacy of food diaries is patient compliance while recording meals. Typically, people do not fill out food diaries because of lack of time and the inconvienance of taking a pad of paper with you wherever you go to eat. That problem can be addressed with emerging technologies commonly available to most patients. That technology is mobile phones and the use of applications on the phones.

Mobile phone usage has increased dramatically over the past twenty years. More and more people are using mobile phones and starting to use them at younger ages. Mobile phones are replacing landlines as the dominant method for voice communication. The invention of the iPhone has taken phones to a new level and taken us into the smart phone era.

Now phones are more computer than voice communication device. With the advent of the smart phone, people are able to do even more with the touch of a finger tip. Smart phones are capable of running different applications (apps) that can let people do anything from flipping a virtual coin to editing their own photos and videos. There are currently apps on the market that allow people to keep track of their food intake.

Daugherty, et al. (2012) performed a study that examined the use of a mobile phone food diary in adults and adolescents. The researchers discovered that both adolescents and adults were able to use the nutrition software on a mobile device adequately enough to complete the study. Overall, this study showed that this electronic record format is a viable alternative to traditional recording methods.

In a practice setting, a phone food diary would either send information straight to the doctor, uploaded to a website that the doctor could access to examine the data, or upload data to a computer so that the patient could print off the information and bring it to their doctor. The doctor would then have all the information necessary to analyze the patient's diet. Many food diary apps automatically sync its information from the phone to a computer automatically. This would eliminate issues of patients losing or misplacing their food diaries and trying to recreate what they ate from memory. Since the food diary is electronic, all entries would be automatically entered on the correct day. This would eliminate problems with date mix-ups. Finally, electronic food records eliminate potential issues with illegiable handwriting. Patients sometimes use shorthand or abbreviations that can make interpreting their diaries difficult for their physician. With all of these potential benefits. it is clear that on paper, electronic food

record are superior to the traditional pen and paper method. However, does this result hold true in a clinical setting?

Galliber, Stewart, Pathak, Werner, Dickinson, & Hickner, 2008 performed a study examining collection outomes between paper forms and PDA forms. For paper records, the authors discovered an error rate of 35%. That was significantly higher than the electronic error rate of 3%. Those percentages translate to 469 errors of omission for the paper forms compared to 43 errors of omission for the electronic forms. This was partly due to the fact that sections of the electronic forms were programmed to not advance to the next question without an answer to the current question. This forced answer format greatly decreased the errors of omission and is a big advantage over traditional paper methods. The questionnaires used in this study were not nutrition related, but the results can be applied to a nutrition setting. The ability to implement forced questions in a nutrition questionnaire would lead to a more complete nutrition picture of the patient. It would force patients to read the question so they could answer it and move on and not simply gloss over and answer questions on autopilot.

Lane, Heddle, Arnold, & Walker (2006) performed a review of randomized controlled trials that compared traditional paper methods of data. In their review of studies, they noted a few advantages that electronic data entry had over the traditional paper method. They state that electronic instruments reduced data entry time by 23%. Another important factor to consider in any form of data recording is patient adherence. Those that used some form of handheld computer showed a 86% adherence rate whereas paper methods only showed a 48% rate. Finally, patient preference plays a big role in the effectiveness of one style over another. The authors of this paper state that 59% of the subjects favored the use of some style of

handheld computer, 19% favored the traditional paper method, and 22% showed no preference whatsoever.

The three factors mentoned by this paper all point towards better compliance by patients with electronic data entry. Electronic devices take less time to enter information when compared to the paper format. Instead of writing out full or partial sentences, patients could select the desired information with a few taps. If something is viewed as taking less time, it is more likely to be done by the patient because it is less invasive in their everyday routine. Adherence to the protocols was better using electronic methods. Patients followed the instructions and protocol better which is certainly desirable from a clinician's viewpoint. Finally, patients will show better compliance if they are given a format that they actually prefer. Since society is turning to handheld computers (PDAs, smart phones, etc) it makes sense to have patients fill in data on the format that they are most familiar with.

Beasley, Riley, Davis, & Singh (2008) also examined paper entry of nutrition data versus an electronic PDA program. The authors discovered that those using the PDA showed a greater adherence to the diet. There was a significant difference between the two methods with electronic showing adherence to the diet in 43% of the days and paper showing adherence to the diet in 28% of the days. This points to the conclusion that the electronic method of recording the food diary actually increased patient compliance with the doctor's diet perscription. Another slightly negative finding from the study was that there were more missing or incomplete food records in the electronic group when compared to the paper group.

This study shows that electronic recording of a food diary improves patient compliance when compared to the traditional pen and paper format. This could be due to the fact that

recording with a PDA provides instant feedback and tracking of the patients diet. This feedback may provide additional motivation to follow a diet that is not obtained with a paper diary. The finding that electronic food diaries had more missing or incomplete entries from compared to the paper diary should not be discounted, but must be weighed against the possible benefits seen in patient compliance. It is understandable that patients would be able to enter data on a paper diary faster using shorthand and abbreviations that they are familiar with. Entering data onto a PDA is more laborious because shortcuts cannot be taken. This is more of burden on the patient, but provides more complete information for the doctor.

Data entry can be faster when entered using a PDA over the paper method. Lal, et al. (2000) examined data entry of burn victims and found using a PDA to record and download information was faster (23%) with fewer errors (58%) as compared to the paper method. It should be examined whether these results would be reproducible in a nutrition setting. This study, if dedicated to just examining the time differential between paper and electronic recording, would provide valuable information for practioners who are trying to decide which format to go with in their office.

One crucial segment of the diabetes problem facing the United States of America is adolescents. Ogden & Carroll (2010) state in their report that in children ageds 2-5 the rate of obesity has increased from 5.0% to 10.4% between 1976/80 and 2007/8. During that same time period in children aged 6-11 the percentage of obesity rose from 6.5% to 19.6% and in children aged 12-19 it changed from 5.0% to 18.1%. This is a huge problem that should be at the forefront of primary care physician's minds when seeing children in their office. In order to help and give advice to children who are facing the health issues of being overweight or obese,

physicians need accurate information on the adolescent's diet. As mentioned above, one of the best ways to gather that information in a comprehensive way is through the use of a food diary. Boushey, Kerr, Wright, Lutes, Ebert, & Delp (2009) state in their research paper that adolescents who were surveyed about food diaries stated that they would not carry the food diary booklet around with them and "would consider altering their food intake to simplify recording." How then are physicians going to gather the information they require in order to help their adolescent patients?

Boushey, Kerr, Wright, Lutes, Ebert, & Delp (2009) contend that novel approaches are needed to assess nutrient intake in children in order to keep them engaged in the process of collecting information. They state that the unstructured eating habits of adolescents contributes to the often seen under-reporting in this age group. Since adolescents are often in a period of growth, they snack and graze to maintain their energy levels. The neccessity of recording their food intake every time they go for a snack may cause frustration and motivate them to "forget" to write down what they eat. The authors suggest trying methods that make the recording of food eaten less of a hassle and more fun.

In their study, Boushey, Kerr, Wright, Lutes, Ebert, & Delp, (2009) recruited 31 adolescents between the ages of 11 and 15. During the course of the study the participants were asked to record their intake of food in five different ways. The first was the traditional pencil and paper format. The second was a PDA that used a drop down selection process in the different food categories. Another method was a PDA that had a camera and allowed participans to take a picture of the food eaten and attach descriptions using the PDA. The fourth method was a disposable camera with accompanying notebook to record pertinent

information for the food. This method was similar in intent to the previous method, but is a little more low tech. Finally, at certain points during the study, their food intake was recorded using the 24 hour recall method.

The authors of this study discovered that the paper and pencil format was liked the least out of the different recording methods. The 24 hour recall and PDA achieved similar ratings among the participants. A large proportion of the participants actually prefered the 24 hour recall to the PDA method. There was 100% agreement that the PDA with camera and disposable camera/notebook were the best liked methods for recording data. These two methods were described as “fun,” “high technology,” and “a lot easier.”

In summary, this study shows that adolescents can be encouraged to keep track of their food intake. It is necessary to give them methods that they view as socially acceptable and are easy to do. In addition, they respond well to methods that have the appearance of being high tech. Based on this study, for the younger generation, it appears like the traditional pencil and paper method will not yield accurate results. It is not favored because it is viewed as embarrassing and a hassle. When dealing with adolescent patients, attempts should be made to incoporate the food diary into their daily routine in the most non-intrusive way possible. In today’s society, that method will most likely involve some form of technology. Since almost every adolescent either has a smart phone or access to some form of higher technology such as a tablet or a touch ipod, food diary apps would be a more acceptable method of recording compared to the pen and paper format.

One argument, that opponents can make against using an electronic food diary, is the complexity of the devices and software that are necessary to extract the needed information.

Opponents can claim that there will always be bugs in the system and that patients who use these methods will not be able to get all the steps correct for a diagnostic analysis to be possible. In their minds, simple equates to better. Six, et al. (2010) set out to show that with repeated use and refinement, performance using an electronic food diary would get better. The adolescent participants were given instruction and training prior to their first use of the dietary recording program. All participants then consumed two meals provided by the researchers and used the electronic food diary at both of them.

Six, et al., (2010) believe that their study demonstrates that improved use of electronic diet recording programs can be attained through additional training activities and interaction design changes. They found that 80% of the participants included all food and beverages in both the before and after shot in the first meal. That percentage increased to 84% during the second meal. This was most likely due to the experience gained while using the program during the first meal. Approximately half of the participants took more than one picture before the meal during the first eating session. This percentage decreased significantly to 22% during the second meal. Both statistics indicate that improvement came with repeated use of the electronic program. The majority of the participants were in agreement that the software they were given to moniter their food intake was easy to use. This finding conributes to the conclusion that the majority of participants who have tested an electronic food diary prefered that to the paper and pencil method.

It is improtant to note, that although the trend is pointing to the benefits of electronic food diaries, handheld devices used for the recording of information such as a PDA or mobile phone do lag behind another device. Haller, Haller, Courvoisier, & Lovis (2009) compared

handheld and laptop computers in electronic data collection. They acknowedge that handheld computers are faster and more accurate when compared to paper and pencil, but that is not the focus of their study. They compared data entered on a PDA and laptop computer.

The authors discovered several interesting items. First, the mean data entry duration significantly increased on the handheld (3.3 minutes compared to 2.0 minutes). Second, the number of typing errors was greater on the handheld (8.4 per 1000 compared to 5.8 per 1000). Third, the handheld had more missing data errors (22.8 per 1000 compared to 2.9 per 1000). These statistics combined paint a convincing picture that a laptop is better suited for data entry than a handheld computer. Even though handhelds may be better than paper and pencil, it is important to not put blinders on and assume that there are no mistakes. It may also be beneficial to select a food diary app that has both a handheld and a laptop component. This would allow patients to enter data in multipe ways and may help decrease errors that are present in the handheld alone.

The papers reviewed so far, point to the conclusion that electronic food diaries are better than the traditional pen and paper format. If that is indeed the case, the question becomes which electronic method is better? Currently, electronic recording of food can be done on a desktop/laptop computer or a handheld electronic device like a PDA or smart phone. This paper will examine some of the apps available for a smart phone to see if they can be used in a clinical setting for the recording of patients food diary. Currently, there is a user review system in place on services like the Apple App Market. However, the general population in not reviewing the apps with the clinical setting in mind. Certain things that are liked by the general population may not translate well into a nutrition practice. Conversely, features that may help

the doctor better serve the patient may not be popular with reviewers. Some comprimise may be needed to find the app that best serves the food diary function for a clinical nutritionist. The objective of this paper is to review some of the most popular apps with a clinical eye and rate them for use in a practice.

Materials and Methods:

For this research project, only apps designed for the Apple iOS system was used. A search was performed on the Apple App store using the term "food diary." It yielded approximately 120 search results. To be included in the study, the application must have contained a way to manually enter food that was eaten, be able to perform an analysis on the contents of the food eaten, and provide some form of a report of calories, nutrients, etc. Using these criteria, the results list was narrowed to twenty applications. These twenty apps were evaluated based upon user ratings, number of reviews, and price. Ten apps with the highest user rating were chosen for inclusion. The ten chosen apps can be seen in Image 1 in order of search results. Each application was downloaded one at a time on an Apple iPhone 4 owned by the author and deleted after evaluation to limit decreases in performance.

Every application was graded on eight categories. The first is ease of use. This category looked at menu design and examined functionality and flow of the menu system. The second was speed of data entry. For this category, the data entry of the two meals was timed using a stop watch and then compared across the different applications. The third category was analysis provided. In this category, the app will be examined to see what type of analysis it provided on the nutritional content of the meals. The optimal analysis is that provided by a desktop computer program. The apps were graded on how many nutrients are analyzed in the food eaten. The fourth category was accuracy of analysis. For this category, the analysis of the nutritional content of the meals was compared to a benchmark to see how close the results were. The fifth category was speed of application. This category examined the

start times and delay between different screens/functions. The sixth category was information presentation. In this category, how the app displays information on nutritional content was examined. Summaries, graphs, and charts were taken into consideration here. The seventh category was elective features. In this category, the app was examined to see what special features were provided to the user. Examples of special features include the ability to join an online community, a barcode scanner for the entering of food, and the ability to write notes about food eaten. Tracking other items in addition to food was examined here. The eighth and final category was data exporting. This category was used to examine the app to see if it was possible to transfer the information gained after tracking food to an online source, email, or other method for transfer to a different party (ex. Clinician).

Each category will be graded on a scale of 1 to 5 with one being poor and five being exceptional. After all categories are scored, an average will be taken to obtain the composite overall score. For each application, two meals will be entered and an analysis will be run. The first meal will be one breast of chicken (4 oz), one cup of brown rice, ½ cup of broccoli, ½ cup of strawberries (4 large), and a glass of 2% milk (20 fluid oz). The second meal is the number one value combination at McDonalds. It consists of a Big Mac, medium fry, and medium Coke. The meals will be entered into the application and analysis will be performed. A summary of every application will be written along with a breakdown of the scores.

For comparison, the same two meals will be entered into the DietMaster version 11 run off of a Windows operating system on a desktop computer. The analysis from DietMaster will serve as the benchmark for accuracy comparisons. This will be calculated by determining the accuracy of total calories, total fat, protein, and carbohydrates, analyzed by the app compared to the benchmark and then averaging the results.

For all apps tested and the control, the demographic information used was a 5’10” male that weights 160 lbs. The listed birth date was December 5th, 1986. The goal was to maintain weight and the activity level was listed as moderate. If asked, the goal period was one year.

Results:

After beginning the evaluation process, three apps were discovered to not meet the inclusion criteria for this study. The first was Pts. Plus. Users can record their food intake in this app and the food is analyzed. However, instead of providing that analysis to the user, the app assigns that food a point value. Based on their demographic data, users are given a point value which they must stay below each week. The second app to be excluded is the Ultimate Food Value Diary. This app is very similar to the first in that it provides points for different foods instead of analyzing them for calories or other nutrient data. The third and final app excluded after the study started is the Total Nutrition app. It does analyze the entered food and provides a fairly comprehensive nutrient analysis. However, this app is primarily designed for use when deciding what to eat for a meal. This app is not a diary in the sense that there is no method present for the recording of meals eaten. This leaves seven apps that were evaluated for this study.

My Fitness Pal Total Rating: 4.3

Maker: MyFitnessPal

User Rating: 5 stars

User Reviews: 7841

Cost: Free

1. Ease of use: Rating 5

   There is a menu bar on the bottom of the screen with five labeled icons. On select screens there are further labeled choices at the top of the screen. Navigation is straightforward with a logical format.

2. Speed of data entry: Rating 4

   Healthy meal: 3:15.32

   Unhealthy Meal: 0:32.93

   Cons: Several steps had to be repeated to select a new food item for one meal.

   Pros: Ability to select food from recent category, frequent, saved my foods, entered meals, and entered recipes

3. Analysis provided: Rating 5

   Total fat, saturated fat, monounsaturated fat, polyunsaturated fat, trans fat, cholesterol, sodium, potassium, total carbs, fiber, sugar, protein, vit A, Vit C, calcium, iron

4. Accuracy of Analysis: Rating 3

   When compared to the DietMaster Software, MyFitnessPal was 85.8% accurate when compared to the control values.

5. Speed of Application: Rating 5

   No problems loading from a cold start. No delay when switching screens or adding food.

6. Information Presentation: Rating 5

   On the home screen there is a calories consumed, calories burned, and calories remaining graphic. It gives daily and weekly summary of nutrients, percentage of calories for protein/carbs/fat pie chart, and net calories line graph. There is also a weight line graph.

7. Elective features: Rating 4

   MyFitnessPal has the ability to add friends and track their progress and send messages. It is also able to record and track weight gain/loss. Has a function to record exercise

broken down into cardio and strength. It can record water intake. The user can record notes about their meals and exercise. It has a barcode scanner. It allows integration with other health apps to increase tracking ability.

8. Data Exporting: 3

   Users have the ability to enter food on either the website myfitnesspal.com or the app and there is automatic syncing between the two. There is no function to transfer the information off the app on the iPhone.

My Net Diary Total Rating: 3.5

Maker: MyNetDiary Inc

User Rating: 4.5 stars

User Reviews: 290

Cost: Free Upgrade to Pro version for 3.99

1. Ease of Use: Rating 4

   There is one main screen with all of the menu options in a list format. User must scroll down to see/access all the different options. Menu labels are clear/concise and navigation is simple.

2. Speed of Data Entry: Rating 3

   Healthy Meal: 2:36.50

   Unhealthy Meal: 1:06.47

   Cons: results can be very jumbled, especially when selecting a broad category like cooked chicken breast

Pros: barcode scanner, favorites, custom food, custom recipes make long term use easier

3. Analysis Provided: Rating 4

   This app provides analysis on calories, total fat, saturated fat, cholesterol, protein, carbohydrates, fiber, sugar, sodium, and calcium.

4. Accuracy of Analysis: Rating 3

   When compared to the DietMaster Software, My Net Diary was 85.6% accurate when compared to the control values.

5. Speed of Application: Rating 5

   There is no perceivable delay in loading or changing screens.

6. Information Presentation: Rating 2

   On the home screen there is a calories consumed, calories burned, and calories remaining graphic. In this version, only a chart to track weight changes is available. Users must upgrade to gain access to other charts and graphs.

7. Elective Features: Rating 4

   App has components to track weight, water consumption, and exercise. Also has an area where users can enter their hip, waist, and neck sizes for tracking. There is the ability to write daily general notes and daily notes on vitamins taken. There is a barcode scanner available. It has articles available to read on the iPhone.

8. Data Exporting: Rating 3

Users have the ability to enter food on either the website mynetdiary.com or the app and there is automatic syncing between the two. There is no function to transfer the information off the app on the iPhone.

My Diet Diary Total Rating: 3.8

Maker: MedHelp

User Rating: 4.5 stars

User Reviews: 35

Cost: Free

1. Ease of Use: Rating 5

   User has the ability to get to all data entry areas from a list menu located on the main screen. Additional menu options are organized into a bar with labeled icons on the bottom of the screen. Navigation is simple and follows a logical format.

2. Speed of Data Entry: Rating 4

   Healthy Meal 2:22.35

   Unhealthy Meal: 1:05.62

   Cons: When selecting a meal item, users are automatically asked to determine portion size. Users must make an additional "click" to enter portion sizes. No ability to create a custom food or recipe.

   Pros: Barcode scanner, recent selections, and frequent selections. Easy to delete unwanted food selections.

3. Analysis Provided: Rating 1

The app provides calories consumed and percentage of calories obtained from carbs, fats, and proteins.

4. Accuracy of Analysis: Rating 4

   When compared to the DietMaster Software, My Diet Diary was 90.4% accurate when compared to the control values.

5. Speed of Application: Rating 4

   There is a small start-up loading time. No delay noted when selecting menu options or switching to new screens except for the forums screen which has a small delay. Small delay is also present when reentering the application from a locked screen.

6. Information Presentation: Rating 4

   On the home screen there is a calories consumed, calories burned, and calories remaining graphic. Graphs are available for weight, calories, and exercise. Good daily summary area on the home page for calories, exercise, and weight.

7. Elective Features: Rating 3

   App tracks food, exercise, weight, and water consumption. Barcode scanner is included. Ability to connect with friends who are using this app once signed in with MedHelp. Users are able to ask questions in the MedHelp forums (in the app) and browse other user questions and answers.

8. Data Exporting: Rating 5

   Users have the ability to enter food on either the website medhelp.org or the app and there is automatic syncing between the two. Users can also print off reports with their

information from the website. There is no function to transfer the information off the app on the iPhone.

Everyday Health Total Rating: 3.9

Maker: Everyday Health, Inc

User Rating: 4 stars

User Reviews: 320

Cost: Free Upgrade for 1.99

1. Ease of Use: Rating 4

   User has the ability to get to all data entry areas from a list menu located on the main screen. Additional menu options are organized into a bar with labeled icons on the bottom of the screen. Navigation is simple and follows a logical format. There are ads present on the bottom of the screen above the menu bar unless the user chooses to upgrade. Due to its placement, mis-taps can lead to different app web pages.

2. Speed of Data Entry: Rating 2

   Healthy: 2:25.07

   Unhealthy: 2:41.06

   Pros: Linear food selection system, frequent selections, customize food, and barcode

   Cons: Did not have preloaded items for McDonalds food items.

3. Analysis Provided: Rating 3

   Calories, total fat, saturated fat, cholesterol, sodium, total carbs, fiber, sugar, and protein

4. Accuracy of Analysis: Rating 5

When compared to the DietMaster Software, Everyday Health was 93.4% accurate when compared to the control values.

5. Speed of Application: Rating 5

   No delay is noted upon start-up. No delay noted when selecting menu options or switching to new screens.

6. Information Presentation: Rating 3

   A numerical daily summary is present at the top of the home screen. There are calories consumed, calories burned, and calories remaining graphic. There are ads streaming on the bottom of our screen (can be removed for 1.99). There is a calorie bar graph that covers the last 7 days and a weight line graph.

7. Elective Features: Rating 5

   The app tracks food and exercise. There is an included barcode. The app provides over 1000 recipes with the associated calorie counts. The app provides a tip page with articles on exercise, food, and other health tips. There is a community page with different forums. There is also a page of different articles.

8. Data Exporting: Rating 3

   Users have the ability to enter food on either the website everydayhealth.com or the app and there is automatic syncing between the two. There is no function to transfer the information off the app on the iPhone.

Calorie Counter Controller Total Rating: 2.1

Maker: Oleg Kuzenko

User Rating: 4.5 stars

User Reviews: 17

Cost: $1.99

1. Ease of Use: Rating 5

   There are six menu options located in a list menu on one screen. Very simple to use.

2. Speed of Data Entry: Rating 1

   Healthy: 3:37.06

   Unhealthy: 2:43.31

   Pros: Ability to search for food by category and name, simple selection process, ability to enter food if you know the calorie count

   Cons: Limited food selection list (ex only three choices for chicken breast), no fast food preloaded suggestions,

3. Analysis Provided: Rating 1

   Only provides a count of calories subtracted from how many the app suggests you consume every day.

4. Accuracy of Analysis: Rating 2

   When compared to the DietMaster Software, Calorie Counter Controller was 65.8% accurate when compared to the control values.

5. Speed of Application: Rating 5

   There are no noticeable delays when selecting menus or different screens.

6. Information Presentation: Rating 1

There are several misspellings. There are no graphs or charts to track the user progress. Past foods eaten are stored so users can look up past meals. It only tracks calories by the day.

7. Elective Features: Rating 1

   There is no tracking of weight, exercise, or water. There are no other features included in this app besides a calorie counter.

8. Data Exporting: Rating 1

   There is no online site associated with this app and no way to transfer data out of the app.

Livestrong.com My Plate Total Rating: 3.5

Maker: Demand Media, Inc

User Rating: 4.5

User Reviews: 35

Cost: Lite-Free Upgrade for 2.99

1. Ease of Use: Rating 4

   Five different labeled menu selections listed as icons on the bottom of the screen. All data entry menus are circle icons located on the main screen. No difficulties found in navigation. There are ads present on the bottom of the screen above the menu bar unless the user chooses to upgrade. Due to its placement, mis-taps can lead to different app web pages.

2. Speed of Data Entry: Rating 5

   Healthy: 2:03.50

Unhealthy: 0:44.63

Pros: Has serving size for each food item, allows you to select from recently eaten foods, frequently eaten foods, custom foods, and custom meals (made on livestrong.com)

Cons: can only make selections for food in number of serving sizes

3. Analysis Provided: Rating 1

   Calories consumed, calories burned, percent calories for carbs, protein and fat consumed.

4. Accuracy of Analysis: Rating 4

   When compared to the DietMaster Software, Livestrong.com My Plate was 91.4% accurate when compared to the control values.

5. Speed of Application: Rating 4

   Slight loading time present whenever the app is opened. No delay when switching screens.

6. Information Presentation: Rating 3

   On the home screen there is a calories consumed, calories burned, and calories remaining graphic. Pie chart of percentage of calories of carbs, fat, and protein consumed, calories consumed bar graph by day, weight line graph by day. There are ads streaming at the bottom of every screen that can be removed by upgrading.

7. Elective Features: Rating 3

   In addition to food, the app also tracks water, weight and exercise. There is a community board where you can post questions or encouragement. The app also has

an achievement system that gives you “mPoints” when certain goals are achieved. These mPoints can then be redeemed for gift cards from different retailers. Short surveys can also be filled out for more points.

8. Data Exporting: Rating 4

   Users have the ability to enter food on the MyPlate section of livestrong.com, the Livestrong app on the iPhone, or the Livestrong app on the iPad and there is automatic syncing between the three platforms. There is no function to transfer the information off the app on the iPhone.

Shape Up Club Total Rating: 3.6

Maker: Sillens AB

User Rating: 5 stars

User Reviews: 5

Cost: Basic version is free or $2.90 a month for a gold subscription

1. Ease of Use: Rating 3

   Menu bar present at the bottom with five labeled icons. Five additional circle icons on the diary page used to track the different areas that are not labeled. There is a learning curve present while figuring out what button tracks what. All other navigation and screen progression is logical.

2. Speed of Data Entry: Rating 5

   Healthy: 2:15.28

   Unhealthy: 0:42.88

Pros: offers a wide selection of ways to enter food amounts. Users can enter food via barcode, favorites, recent, custom food, custom meals, and categories.

Cons: Multiple taps needed to enter a food item

3. Analysis Provided: Rating 2

   The app provides calories, protein, fats, and carbs. The app also breaks calories down into percentage of fats, proteins, and carbs.

4. Accuracy of Analysis: Rating 5

   When compared to the DietMaster Software, Shape Up Club was 94.2% accurate when compared to the control values.

5. Speed of Application: Rating 5

   No delay present when opening the app, reentering the app from a locked screen, or changing menus/screens.

6. Information Presentation: Rating 4

   On the home screen there is a calories consumed, calories burned, and calories remaining graphic. The app provides a line graph for weight and waist measurements. The app also provides a bar graph for daily calorie intake. It breaks calorie intake into percentage of protein, carbs, and fat.

7. Elective Features: Rating 2

   The basic app version allows tracking of weight, and waist size. Upgrading to gold gains water tracking, fruit an veggie tracking, ability to write daily comments, body fat tracking, arm size tracking, an chest size tracking.

8. Data Exporting: Rating 3

Users have the ability to enter food on either the website shapeupclub.com or the app and there is automatic syncing between the two. There is no function to transfer the information off the app on the iPhone. Need to upgrade to gold to gain access to data porting and information printing.

After the evaluation of the different apps was complete, it was determined that My Fitness Pal had the highest average rating (4.1). For a comparison of ratings between the apps, see Table 1. This app really scored high in the analysis provided category (5). It provided anaylsis on sixteen different nutrients which was the most when compared to other apps. Refer to Table 3 for a rundown on the different nutrients analyzed by each app. The app also scored well in the speed of data entry category (Table 2). It had the fastest unhealthy meal entry time, but it had one of the slower healthy meal entry times. That was primarily due to the high number of choices that needed to be looked through before making a selection.

The app that scored the lowest was Calorie Counter Controller by Oleg Kuzenko (2.1). This app had some high category scores by being simple to use, having a nice flowing menu system, and providing accurate analysis. Its total score was brought down by only providing an analysis of calories consumed, not having any elective features, and not having any means of exporting data. These downfalls make this app unsuitable for use in a clinical setting. The apps that fell between this app and the My Fitness Pal also had their high and low points, but ultimately they all fell short when examined for use in a clinical setting.

Discussion:

The goal of this paper was to examine whether an app based off of a smart phone was appropriate for use in a clinical setting. There are a number of advantages to using an

electronic food diary. Increased patient compliance, legible records, more complete information, and up to date accurate records are just some of the benefits of electronic food diaries over a paper format.

With that in mind, the question to be answered was if any apps currently available were suitable for use by a primary care physician working with a patient's nutrition. An app for use in a clinical setting must have some way for a physician to see the data. It must provide accurate information up-to-date information that a physician can rely on when deciding the best course of treatment. The app must provide a fairly detailed analysis of food consumed so the physician has a good base of knowledge to work with. The app must be easy to navigate and user friendly to keep patients in compliance and not frustrated by what they have to work with.

Besides having the highest rating out of the apps reviewed, My Fitness Pal would serve well in a clinical setting due to the volume of information it provides. The doctor receives more information than how many calories are ingested and the percentage of protein, carbohydrates, and fat. The amount of information provided will serve a physician well when it comes time to examine potential treatment avenues. My Fitness Pal also has an online component that allows the user to enter data online or on the iPhone with automatic sync between the two components. This allows for greater versatility for the patient which will increase patient compliance. Doctors can look at their patient's data online via their account, through information the patient prints offand brings into the office, or on the patient's smart phone in the office. In today's day and age, it is important to have versatility for the patient in completing information and for the doctor in accessing that information.

My Fitness Pal is the author's choice for the best app for a clinical setting. However, it is entirely possible that patients would prefer a different app. The best app from a patient's perspective is most likely Everyday Health. The menu progression system is very similar, but Everyday Health is predominantly colored with shades of green whereas My Fitness Pal's dominant color is black. The difference in color scheme brightens up Everyday Health compared to the darker tones of My Fitness Pal. My Fitness Pal has a better presentation of information and amount of analysis provided, but Everyday Health has more elective features like recipes, a forum, and articles on the app. The bottom line, while Everyday Health may appeal more to the patient, My Fitness Pal is the better option for the clinician. A clinician can work with Everyday Health, but will gain more information and be better off from a clinical standpoint with My Fitness Pal.

In this paper, seven different apps were evaluated to determine their effectiveness in a clinical setting. Although there is a review system in place in the Apple App Market, it is based solely on user reviews that are not done with the clinical setting in mind. It is also possible to be misled by apps with really high ratings that are the product of only a few reviews. For instance, Calorie Counter Controller, which received the lowest rating in this paper (2.1) had one of the higher ratings on the App market (4.5 stars). What can be lost when searching for the correct app to fit the needs of a practice is the fact that the 4.5 star rating was the product of only 17 revoews. There currently are no other studies in the literature that examine and rate the popular nutrition apps from a clinical perspective. This study was necessary to fill that gap in the literature and help physicians concerned about their patient's nutritional status find the app that is best suited for them.

Even though this study presents an objective review of the apps from a clinical standpoint, there are still areas of potential bias present. First, the author of this paper is a Doctorate of Chiropractic student who is also working towards obtaining a Masters in Nutrition. All judgements made on what is necessary from a clinical standpoint were decided based on classroom studies and limited experience in student and out-patient clinics. Secondly, with the rating system. Even though much of the analysis of the apps was objective (time spent entering data, number of analyses, number of elective features, etc), the rating assigned to the categories for each app is still subject to examiner bias. This bias could be partially mitigated in future studies by having mutiple reviewers rate the apps. Finally, two of the categories (ease of use and speed of app) were completely subjective and others had subjective components to them. For example, the elective features category. The objective component was the number of elective features present while the subjective was the type of feaures present. Any study performed that is tasked with rating a subject will fall prey to some of these biases.

Throughout this study, areas for potential growth in the apps was noted. One of the biggest areas is data exporting. None of the apps examined was capable of exporting data from the app directly. One of the apps was able to do so after a fee was paid for an upgrade. This is an area that would be highly beneficial to develop. It would allow the physicians direct access to data instead of having to rely on patient printing off records or giving the doctor access to online accounts. It would provide for quicker commuication between patient and doctor. Doctors would not have to wait for the patient's next visit for an update on their nutritional status if patients could email the doctors reports from their food diary on their phone. Finally, it would make the patient's burden less which in turn would help increase patient compliance.

Patients would not be responsible for printing of reports and remembering to bring them in. Instead they can send the reports directly to their physician with the touch of a button.

Another area of potential growth is in the recording of vitamins. Only one app mentioned vitamin/supplement recording and the user had to enter that free-form into a note section. More and more people are taking vitamin and supplements to fill in the gaps in their diet. A food diary that does not take note of that is missing the complete picture. That is not a good situation for the doctor or patient to be in. This should not be a big jump for developers to make and research can be done on this subject. For example, there is research being done to examine the feasibility of recording dietary supplements electronically in addition to the food consumed. (Harnack, Stevens, Van Heel, Schakel, Dwyer, & Himes, 2008) Often patients forget what nutritional supplements they are taking, when they take them, and how big of a dose they consume. A standardized recording method that is used in conjunction with an electronic food diary could increase patient compliance with recording supplement information. In essence, two birds are being hit with one stone if one program could take care of both supplements and diet recording. This would only increase the information available to the doctor when examining a patient's diet.

Finally. another avenue that is rapidly being explored and deserves to have more research performed was already touched on briefly in this paper. That method is the use of a camera to capture images of the food consumed. The current method used is taking a picture of what is eaten so that the doctor can review the images and estimate portion size. Khanna, Boushey, Kerr, Okos, Ebert, & Delp (2010) describe a program that would analyze an image of a meal, identify each food item present, accurately estimate the portion of each food, and

compare the portion of each food against a national database to provide a nutritional composition breakdown. With this method, the goal is to erase subjective influences and provide a completely standarized objective analysis of food eaten.

This is not an easy task however. A two dimensional image must be converted to three dimensions in order to obtain accurate volume estimations and identifications. One researcher states that segmentation of food is the key to 3D reconstruction stating "…False segmentation caused by shadows and reflections in an image and noise along segmentation boundaries can seriously deteriorate the accuracy of volume estimates." (Chae, et al., 2011) One of the components to 3D reconstruction is camera calibration. It is necessary for the program to be able to calibrate the image obtained from a camera in order to accurately reconstruct it. Woo et al., (2010) describe the use of a fiducial marker in a checkerboard pattern about the size of credit card that is included in every image. This marker allows them to have a reference in the picture that allows them to determine the camera's parameters and obtain the necessary 3D coordinates. Two different types of information are extracted from the picture, color features and texture features. (Zhu, et al., 2008) This leads to food identification. Volume estimation is done through comparison with the fiducial marker which gives camera parameters and size reference point. (Zhu, et al., 2010) Finally, nutritional content is assessed through comparison with USDA's national database. All of this can either be done on the phone or the information can be sent to a server for processing. On the phone is beneficial because a network connection is not needed, but battery consumption is high. (Zhu, Bosch, Boushey, & Delp, 2010)

The concept of this study could be expanded on in future research. This paper dealt specifically with the Apple App market and iOS opperating system. Another similar study could

be performed on the Android market and Linux operating system. There would be some apps that are present in both systems, but there are apps that are unique and developed specifically with one operating system in mind. A similar review done on the Linux system utilizing the Android market would complement this study and provide the inquiring clinician with a full review picture so that the best apps can be chosen for use in the clinical setting.

Another topic of future study is examinig the online componens of the electronic food diary apps. This paper touched on the concept briefly to determine if the apps could sync to an online website and allow the input of data on a different platform. The purpose of this paper was not to review the online capabilities of the selected apps. However, that does form a part of the complete picture of an app. Some apps that did not score as high may have an online component that elevates them beyond the top apps in this study. Some apps may have online components that make them even more clinically relevant than the mobile version alone. More time and resources would be needed to do a full review electronic food diaries.

Conlusion:

This paper was started with the intent to examine apps available to the general public to decide if any were suitable for use in a clinical setting. It was determined that there are apps suitable for use in a nutrition practice. My Fitness Pal not only rated the highest out of the apps reviewed, it also contained the necessary components to be used in a clinic.

The use of technology in food diary recording has shown and continues to show great promise. Current methods offer greater convenience to the patient and better information to the doctor. Methods that are being explored and developed for future use have the potential to take subjective estimation and identification out of the picture entirely. The ultimate goal is

to get the most accurate information from the patient that is possible and then turn around and use that information to provide sound nutritional advice and counseling to promote healthy lifestyle changes. Moving forward to combat the health issues facing the US, doctors need reliable methods of gathering data that limit bias and increase accuracy.

Primary care physicians are already facing challenges in the treatment of patients that suffer from conditions related to nutrition. In order to best face the challenges posed during the treatment of their patients, they need to have accurate information regarding their health status. With the explosion of handheld devices, such as smartphones, the stage is set for doctors to take advantage of what their patients are already using. Often some form of a handheld computer is already playing a crucial role in the day to day activities of their patients. It makes sense to use a food diary that is supported by devices that are integrated into the daily lives of patients. This paper presented an evaluation of electronic food diaries designed work on smart phones. With the review that was performed in this paper, doctors now have the information needed to make an informed decision on what apps can be best integrated into their individual clinical setting. Using the information presented in this paper, doctors can begin applying new and emerging technologies in their nutrition practice to gain higher quality information about their patient's diet in a more timely fashion with less burden placed on the patient.

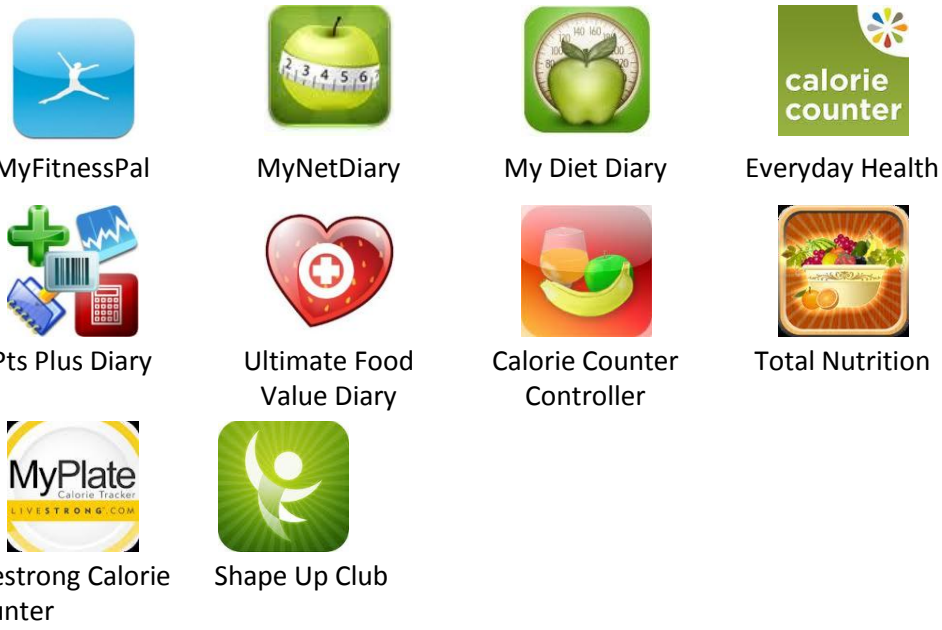

Image 1: Original App Icons

	My Fitness Diary	My Net Diary	My Diet Diary	Everyday Health	Calorie Counter Controller	Livestrong.com My Plate	Shape Up Club
Ease of use	5	4	5	4	5	4	3
Speed of Data Entry	4	3	4	2	1	5	5
Analysis Provided	5	4	1	3	1	1	2
Accuracy of Analysis	3	3	4	5	2	4	5
Speed of App	5	5	4	5	5	4	5
Information Presentation	5	2	4	3	1	3	4
Elective Features	4	4	3	5	1	3	2
Data Porting	3	3	5	3	1	4	3
Total Rating	4.3	3.5	3.8	3.9	2.1	3.5	3.6

Table 1: Breakdown of App Ratings

	Healthy	Healthy Rating	Unhealthy	Unhealthy Rating	Total Rating
My Fitness Pal	03:15.3	2	00:32.9	5	4
My Net Diary	02:36.5	3	01:06.5	3	3
My Diet Diary	02:22.4	4	01:05.6	3	4
Everyday Health	02:25.1	4	02:41.1	1	2
Calorie Counter Controller	03:37.1	1	02:43.3	1	1
Livestrong.com My Plate	02:03.5	5	00:44.6	4	5
Shape Up	02:15.3	5	00:42.9	4	5

Table 2: Time of Data Entry

	Diet-Master	My Fitness Pal	My Net Diary	My Diet Diary	Everyday Health	Calorie Counter Controller	Livestrong.com My Plate	Shape Up
Calories	1829	1695	1733	1655	1709	1204	1672	1732
Total Fat (g)	62	56	47		59			55
Sat Fat (g)	15	17	13		17			
Mono Fat (g)	22	1						
Poly Fat (g)	7	1						
Trans Fat (mg)	1.29							
Cholesterol (mg)	162	110	95		155			
Protein (g)	78	54	75		69			83
Carbohydrates (g)	242	220	183		234			226
Fiber (g)	18	16	23		13			
Sugar (g)	27	84	65		85			
Sodium (mg)	1986	1496	2238		1661			
Potassium (mg)	1167	484						
Calcium (mg)	894	540	710					
Iron (mg)	10	3.4						
Vit A (IU)	2760	1579						
Vit C (mg)	150	195						
Thiamin (mg)	1							
Riboflavin (mg)	1							
Niacin (mg)	11							
Vit B6 (mg)	0							
Vit B12 (mcg)	3							
Vit D (IU)	120							
Folate/Folic Acid (mcg)	216							
Magnesium (mg)	582							
Phosphorus (mg)	1167							
Zinc (mg)	6							
Percent Accuracy		85.8%	85.6%	90.4%	93.4%	65.8%	91.4%	94.2%
Accuracy Rating		3	3	4	5	2	4	5
Analysis Rating		5	4	1	3	1	1	2

Table 3: Analysis Provided and Accuracy

Works Cited

Beasley, J., Riley, W. T., Davis, A., & Singh, J. (2008). Evaluation of a PDA-based Dietary Assessment and Intervention Program: A Randomized Controlled Trial. *Journal of the American College of Nutrition , 27* (2), 280-286.

Boushey, C. J., Kerr, D. A., Wright, J., Lutes, K. D., Ebert, D. S., & Delp, E. J. (2009). Use of technology in children's dietary assessment. *European Journal of Clinical Nutrition , 63*, 50-57.

Chae, J., Woo, I., Kim, S. Y., Maciejewski, R., Zhu, F., Delp, E. J., et al. (2011, February 7). Volume Estimation Using Food Specific Shape Templates in Mobile Image-Based Dietary Assessment. *Proceedings of SPIE* .

Collison, K. S., Zaidi, M. Z., Subhani, S. N., Al-Rubeaan, K., Shoukri, M., & Al-Mohanna, F. A. (2010). Sugar-Sweetened carbonated beverage consumption correlates with BMI, waist circumference, and poor dietary choices in school children. *BMC Public Health , 10*, 234.

Daugherty, B. L., Schap, T. E., Ettienne-Gittens, R., Zhu, F. M., Bosch, M., Delp, E. J., et al. (2012). Novel Technologies for Assessing Dietary Intake: Evaluating the Usability of a Mobile Telephone Food Record Among Adults and Adolescents. *Journal of Medical Internet Research , 14* (2).

Ershow, A. G., Peterson, C. M., Riley, W. T., Rizzo, A., & Wansink, B. (2011, March). Virtual Reality Technologies for Research and Education in Obesity and Diabetes: Research Needs and Opportunities. *Journal of Diabetes Science and Technology* , 212-224.

Galliber, J. M., Stewart, T. V., Pathak, P. K., Werner, J. J., Dickinson, L. M., & Hickner, J. M. (2008). Data Collection Outcomes Comparing Paper Forms With PDA Forms in an Office-Based Paient Survey. *Anals of Family Medicine , 6* (2), 154-160.

Haller, G., Haller, D. M., Courvoisier, D. S., & Lovis, C. (2009). Handheld vs. Laptop Computers for Electronic Data Collection in Clinical Research: A Crossover Randomized Trial. *Journal of the American Medical Informatics Association , 16* (5), 651-659.

Harnack, L., Stevens, M., Van Heel, N., Schakel, S., Dwyer, J. T., & Himes, J. (2008). A computer-based approach for assessing dietary supplement use in conjunction with dietary recalls. *Journal of Food Composition and Analysis , 21*, 578-582.

Khanna, N., Boushey, C. J., Kerr, D., Okos, M., Ebert, D. S., & Delp, E. J. (2010). An Overview of The Technology Assisted Dietary Assessment Project at Purdue University. *ISM* , 290-295.

Lal, S. O., Smith, F. W., Davis, J. P., Castro, H. Y., Smith, D. W., Chinkes, D. L., et al. (2000). Palm computer demonstrates a fast and accurate means of burn data collection. *Journal of Burn Care and Rehabilitation , 21* (6), 559-561.

Lane, S. J., Heddle, N. M., Arnold, E., & Walker, I. (2006). A review of randomized controlled trials comparing the effectiveness of hand held computers with paper methods for data collection. *BMC Medical Informatics and Decision Making , 6* (23), 1-10.

Ogden, C., & Carroll, M. (2010). *Prevalence of Obesity Among Children and Adolescents: United States, Trends 1963-1965 Through 2008-2008.* National Center for Health Statistics, Division of Health and Nutrition Examination Surveys. Atlanta: Centers for Disease Control.

Six, B. L., Schap, R. E., Zhu, F. M., Mariappan, A., Bosch, M., Delp, E. J., et al. (2010). Evidence-based development of a mobile telephone food record. *Journal of the American Dietetic Association , 110* (1), 74-79.

Stumbo, P. J., Weiss, R., Newman, J. W., Pennington, J. A., Tucker, K. L., Wiesenfeld, P. L., et al. (2010, October 27). Web-Enabled and Improved Software Tools and Date Are Needed to Measure Nutrient Intakes and Physical Activity for Personalized Health REsearch. *The Journal of Nutrition* , 2104-2115.

Vetter, M. L., Herring, S. J., Sood, M., Shah, N. R., & Kalet, A. L. (2008). What Do Resident Physicians Know about Nutrition? An Evaluation of Attitudes, Self-Perceived Proficiency and Knowledge. *Journal of the American College of Nutrition , 27* (2), 287-298.

Woo, I., Otsmo, K., Kim, S., Ebert, D. S., Delp, E. J., & Boushey, C. J. (2010, January 1). Automatic portion estimation and visual refinement in mobile dietary assessment. *Proceedings of SPIE* , 7533-7553.

Zhu, F., Bosch, M., Boushey, C. J., & Delp, E. J. (2010). An Image Anaysis System for Dietary Assessment and Evaluation. *Proceedings International Conference on Image Processing* , 1853-1856.

Zhu, F., Bosch, M., Woo, I., Kim, S., Boushey, C. J., Ebert, D. S., et al. (2010). The Use of Mobil Devices in Aiding Dietary Assessment and Evaluation. *IEEE Journal of Selected Topics in Signal Processing , 4* (4), 756-766.

Zhu, F., Mariappan, A., Boushey, C. J., Kerr, D., Lutes, K. D., Ebert, D. S., et al. (2008, March 20). Technology-Assisted Dietary Assessment. *Proceedings of SPIE* , 1-16.