Interactive Computer-Tailored Nutrition Education

Dawn K Aldridge

Office of Analysis, Nutrition and Evaluation

Food and Nutrition Service, USDA

2006

Introduction

This paper will cover what research findings, published between 1995 and 2005, say about the effectiveness of interactive computer tailoring of nutrition education. First, we will define message tailoring and review what we know about its effectiveness in a general sense. Then, we will discuss recent evidence concerning the effectiveness of nutrition education that incorporates an interactive computer-tailored approach.

What is message tailoring?

Message tailoring utilizes data on personal characteristics to educate and persuade individuals to change their behavior (Kreuter et al., 1999.) While group-targeted materials are designed to reach particular subgroups of people that share demographic characteristics such as age, gender or race, tailored messages are individualized based on assessments of personal characteristics, needs, and targeted outcomes. Characteristics used to build tailored messages may include demographic descriptors; but, they also include health, nutrition and psychological characteristics such as the state of the individual's health, diet quality, extent of nutrition knowledge and attitudes towards nutrition, themselves and society. In a review of message tailoring, Brug et al. (2003) state that behavioral determinants -- including intentions, motivations, attitudes, social influences, and perceived self-control -- contribute up to 50% of the variance in fat intake and that demographic characteristics have a more distal impact on eating habits than behavioral factors. Brug et al. (2003) argue that demographic targeting is only useful if the targeted group is homogenous enough in psychosocial beliefs.

Why should message tailoring work?

The elaboration likelihood model (Petty and Cacioppo, 1986) holds that, when considering persuasive messages intended to prompt behavior changes, people are likely to process personally relevant messages more thoughtfully than generic messages and are more likely to respond to messages receiving more of their attention. Message tailoring is intended to make messages more personally relevant, thus garnering deeper attention from the reader. What type of tailoring makes messages more relevant and interesting to a reader? A number of behavioral change theories suggest that personal attitudes and characteristics condition an individual's response to nutrition education messages. These theories indicate *how* to tailor messages so that they are more relevant to the individual. For example, a tailoring scheme based on a stages of change model (e.g., The Transtheoretical Model, Prochaska and Velicer, 1997) consider not only areas of concern in the client's diet (e.g., inadequate vegetable consumption), but also, the client's level of readiness or motivation to change their behavior. Tailoring based on the Health Belief Model would center on the client's perception of the risks and benefits associated with changing behavior. Meanwhile, tailoring based on self-efficacy theory would focus on individuals' beliefs about their ability to change in areas of concern (Perry and Bauer, 2001.) As will be seen in the studies reviewed here, many message tailoring interventions combine elements of several theories of behavioral change.

Methods of Message Tailoring

The most direct and individualized method of message tailoring is inter-personal communication, that is face-to-face nutrition counseling (Kreuter et al., 1999.) In a counseling environment the nutrition educator learns about a client's personal characteristics through conversation, perhaps with the aid of a written assessment tool, and adjusts their counsel based on feedback from the client. For example, a counselor may ask the client about their eating habits and determine that the client has a diet high in saturated fat. By asking further questions, the counselor also learns that the client knows that a diet high in saturated fat may lead to cardiovascular disease and that the client is concerned because of family medical history. Having identified an area of concern that the client appears ready to tackle would lead the practitioner to educate the client about dietary changes to lower saturated fat intake. This approach is very individualized, but because of the labor investment required, it is costly and limited in reaching large, diverse populations.

With the advent of automated information technology, tailored communication for the masses has become possible. Computers are capable of analyzing a vast amount of data on personal characteristics and generating unique nutrition education materials for individuals at a relatively low cost compared to individual counseling. Personal data can be captured in numerous ways, through interpersonal interviews, written surveys, off or on-line computerized surveys, interactive computerized tutorials, or even by collecting answers to recorded questions heard over the telephone. After personal information is entered into a database, a computer can generate a set of tailored messages that may be printed and provided to the client to keep. Depending on the mode of data collection, tailored feedback may come to the individual in the form of immediately printed materials, verbal recordings heard by phone, on-screen audio-visual information, or printed materials generated at a later time and sent by mail or e-mail.

Several reviews (Skinner et al., 1999; Kreuter et al., 1999; Brug et al., 1999; Brug et al., 2003) of research on computer-generated tailored nutrition messages have concluded that tailored education is more effective than generic education, including education that is targeted to demographic subgroups, because tailored messages are more relevant to personal needs and beliefs, and, thus, are more motivating. The reviews showed that tailored messages are more likely to be read, remembered, and viewed as relevant compared to generic materials. They also showed that tailored messages were more effective in bringing about behavior change. The evidence is strongest with respect to dietary fat, although limited positive results have been seen with respect to increasing fruit, vegetable, and fiber intake. Several areas merit further inquiry. For example, we do not have enough information to determine whether people are more responsive to tailored messages about certain topics (e.g., fat intake) than about others (e.g., fruit and vegetable intake) (Skinner et al., 1999). We also do not know a lot about what types of people are more likely to respond positively to computer-tailored nutrition education. According to Brug et al. (2003) most research on computer tailoring has been done with self-selected samples that tend to be highly educated, largely female, and personally motivated to change. Therefore, it is impossible to draw conclusions about sub-groups such as low-income mothers. The same is true for the research on interactive tailoring presented in this paper. Finally, we do not know how the format (e.g., newsletter, personal letters, computer print-outs, brochures, videos) of tailored materials impacts people. Much work remains to be done to understand the impact of tailoring and mediating factors that condition individual responses to computer-tailored nutrition education such as level of education, income, message format, message topic, and psychosocial factors.

The more recent of the reviews (Brug et al., 2003) suggest that the future of computer-tailored nutrition education lies in interactive technology such as PC- or web-based interactive programs that offer immediate feedback to users and enable users to follow educational pathways based on their interests and responses in addition to offering printed feedback. According to Brug et al., non-interactive tailoring does not take full advantage of the potential of computer tailoring because of the lack of immediate feedback and interaction. Since Brug et al. (2003) was released, several studies of interactive computer-tailored nutrition education have been published. This paper will review these more recently completed studies.

Literature Review

We identified six articles published between 1999 and 2004 that offer primary evidence of the effectiveness and/or acceptability of interactive computer-tailored nutrition education. These include two using computerized telephone counseling (Glanz et al., 2003; Delichatsios et al., 2001), three using PC-based multi-media programs (Campbell et al., 1999; Campbell et al., 2004; Irvine et al., 2004), and one using a web-based intervention (Oenema et al., 2001). Table 1 summarizes key features and results of the studies reviewed here.

Telephone Linked Care (TLC)

The Telephone Linked Care (TLC) study evaluated the effectiveness of a computerized telephone conversation system that delivered tailored nutrition education. Users of TLC called in to the computerized system and provided answers to questions via telephone keypads. Tailored nutrition education was provided based on callers' answers. Two sets of results were reported. Delichatsios et al. (2001) discusses the dietary outcomes based on intake assessments, while Glanz et al. (2003) discusses participant reactions to the system.

The telephone-linked care (TLC) system was developed to provide a convenient, low-cost, time-saving alternative to direct preventive counseling by health care professionals. The study sample included 298 members of a managed care organization ranging from 25 to 89 years of age. The sample was 72% female, 59% married, 77% college educated, 47% white, 42% black, and 47% self-reported to be in at least good health. Of these, 148 were randomly assigned to the nutrition education intervention (TLC-EAT). The rest were assigned to a physical activity education group (TLC-RUN) which also served as the comparison group for the TLC-EAT study. The participants were allowed to access nutrition education by calling the system at any time for a

Table 1: Summary of Reviewed Studies on Computer-Tailored Nutrition Education

Citation	Intervention	Population	Study Design	Theoretical Basis	Main Effects *(subgroup analyses not included)*
Campbell et al. 1999	StampSmart: 1 exposure to 30-minute interactive video program	Female Food Stamp recipients (n=378)	RCT	SCT SOC SM	**1-3 months post- intervention:** + Knowledge of low-fat foods** + SOC* + Baked meat in oven* + Ate graham crackers for snacks** + Ate pretzels for snacks**
Campbell et al. 2004	FoodSmart: 1 exposure to 30-minute interactive video program	Female WIC recipients (n=307)	RCT	SCT SOC SM	**1-2 months post-intervention:** + Self-efficacy for low-fat dairy* + Knowledge of low-fat foods* + Knowledge of infant feeding*
Delichatsios et al. 2001	Telephone Linked Care (TLC – EAT): 6 modules by phone over 6 months, repetition of modules allowed	Health care employees (n=298) 72% female 77% college educated	RCT	SCT	**End of 6-month intervention:** + Fruit intake 1.1 serving per day* + 9 global diet score, 100-point scale* + Fiber intake 4 g/d* - Saturated fat as % of Kcal 1.7%*
Glanz et al. 2003	TLC – EAT	TLC – EAT completers (n=103)	Follow-up survey	SCT	**End of 6-month intervention:** *100-Point Scale:* Overall satisfaction = 73.0 Helpfulness = 70.3 *5-Point Scale:* Usability = 4.05 Amount of contact = 3.87 Realism/Credibility = 3.1 Motivation = 3.48 Effect on mediators = 3.81
Irvine et al. 2004	Interactive pc-based multi-media program available for repeated access over 60 days at work	Hospital and corporate employees (n=517)	RCT with wait-list control and cash ($30) incentive	SOC TRA HCT SCT	**30 days post-intervention:** + Fat eating behaviors*** + F&V consumption*** + Recommended behaviors*** + SOC*** + Attitude re: diet importance** + Intent to decrease fat** + Self-efficacy to decrease fat* **60 days post-intervention:** + Fat eating behaviors*** + F&V consumption*** + Recommended behaviors*** + SOC*** + Attitude re: diet importance*** + Intent to decrease fat*** + Self-efficacy to decrease fat***
Oenema et al. 2001	Web-based program impact on awareness and intentions regarding fat, and fruit and vegetable intake	Employees and students of adult education institutions in the Netherlands (n=198)	RCT, pre/post test design	PAPM	+Intend to eat less fat** +Intend to change diet (eat more F&V)*** Higher self-rated *fat intake compared to others* ** Higher self-rated *fruit intake compared to others** +Changed opinion about own diet quality***

*P=0.05 ** P=0.01 *** P=0.001

Study Design Key: RCT = Randomized Control Trial

Theory Key: SCT = Social Cognitive Theory; SOC = Stages of Change; SM = Social Marketing; TRA= Theory of Reasoned Action; HCT= Health Communication Theory; PAPM = Precaution Adoption Process Model period of six months. TLC-EAT included six five-to-ten minute "conversations" which assessed participants' eating behaviors in major food groups and provided general nutrition education and counseling to modify poor dietary behaviors based upon user input. If a participant called a seventh time, the cycle of conversations was restarted.

Delichatsios et al. (2001) assessed dietary impact of the intervention using two assessment tools administered at baseline and 3 and 6 months into the intervention. The instruments included a lengthy 131 question food frequency questionnaire (FFQ) and a short 18-item dietary assessment tool. Using both instruments, they calculated intake from five food groups (fruits, vegetables, red and processed meats, whole fat dairy foods and whole grain foods) and estimated nutrient intakes. In addition, they used the FFQ to create an overall diet quality score. Response rates for the shorter instrument were significantly higher than for the FFQ. Using FFQ results, they found that, over a period of six months, TLC-EAT participants reported increasing their consumption of fruit by an average of 1.1 servings, increasing dietary fiber intake, and decreasing saturated fat intake. These outcomes were supported by findings from the shorter instrument. They also found that the intervention increased the global diet score by 8.9 points out of 100.

It is important to note that 24% of the participants never accessed TLC-EAT, 36% accessed it 1-10 times, 23% did so 11-20 times, and 18% accessed it 21 times. Median use among all participants was 6.5 times and 11 times among those who used it at least once. Based on the shorter 18 question survey, participants who used the program more times report higher decreases of fat intake and increases of fruit and fiber intake. The study showed a dose-response relationship with respect to fruit, fiber and saturated fat intake. Unfortunately, it is unclear whether the dose-response relationship was due to higher levels of exposure to the intervention or to a higher level of motivation among participants who accessed TLC-EAT more.

Glanz et al. (2003) carried this work further by querying participants about their attitudes toward, and perceptions of, the TLC system. Of the 148 participants in the TLC-EAT program, a sub-sample of 103 with similar characteristics completed the attitudes and perceptions survey after being in the TLC-EAT program six months.

On a 100 point scale, users gave the TLC-EAT average ratings of 73 for satisfaction and 70 for helpfulness. On a scale of one to five, users, on average, rated the TLC-EAT's usability at 4.05, realism and credibility at 3.1, amount of contact with TLC-EAT at 3.9, effect on mediators (e.g., understanding of benefits, awareness) and behavior at 3.8, and their motivation to use it at 3.5. When asked about the most important benefits of TLC-EAT, participants stated that TLC-EAT increased their awareness and understanding of the benefits of healthy eating, reminded them to eat better, encouraged them to change their habits, and motivated them to change. When asked about how TLC-EAT could be improved, many participants indicated satisfaction, while others suggested changes in content such as including more recipes. When compared with results from the TLC-RUN group, TLC-EAT participants reacted more favorably to the system, but no precise explanation is available for the difference.

These TLCs studies have two important weaknesses. First, the comparison group also received education (concerning physical activity) using TLC. Therefore, unfortunately, treatment effects can only be attributed to content rather than method of delivery. In addition, the final sample was comprised of self-selected health care workers. The degree of TLC use was highly self-selected. Of the 2,884 people who were contacted, only 298 completed the screening, were eligible and agreed to participate, and of the 148 assigned to the intervention group, nearly a quarter did not even use the system.

Personal Computer-Based Multi-Media Programs

Another group of studies investigated interventions that provided tailored interactive multi-media nutrition education through participants' use of a personal computer (PC). Campbell et al. conducted two studies in 1999 and 2004, and Irvine et al. conducted one in 2004. Study descriptions, results and limitations are discussed for each study.

The first study (Campbell et al., 1999) piloted the StampSmart program among 378 women participating in the Food Stamp Program. Of these, 32% had at least a high school education, 85% were African-American, 73% reported a high level of autonomy in food purchasing and preparation, and 60% felt they needed to lose weight. Individuals were randomly assigned to control (n=212) or intervention groups (n=165). One participant was dropped from the analysis sample due to missing data. The groups had similar characteristics except that a small but statistically significant higher proportion of the control group (62%) reported feeling the need to lose weight compared to the intervention group (59%). All study participants completed baseline surveys and follow-up surveys at one to three months post intervention. The intervention group also completed an immediate post-program survey.

The StampSmart program was offered in a stand-alone kiosk in the Food Stamp office that users could access without the help of Food Stamp office staff. Based on preferences elicited from formative interviews of 54 female Food Stamp recipients, the interactive multi-media program was modeled after a television soap opera interspersed with infomercial-type nutrition messages. The one-time, 30-minute program focused on strategies to increase participants' sense of self-efficacy to reduce their fat intake. The strategies included plot lines that showed behavior changes, interactive exercises and behavioral messages based on the individual's stage of readiness to change. Stages of change, proposed in the Transtheoretical Model of Change (Prochaska and Velicer, 1997), include precontemplation, contemplation, preparation, action, and maintenance. The program also offered tailored feedback based on responses to the baseline survey given to the subjects at the beginning of the computer intervention.

Survey measures included stages of change related to reducing fat intake; sense of self-efficacy to change behavior; nutrition knowledge; perceived overweight; autonomy over food shopping, meal planning and preparation; a dietary fat score based on a 16 item FFQ; eating behaviors related to fat consumption; and, finally, participant assessments of the program. At the one to three month follow-ups, the intervention group was significantly more knowledgeable about low-fat foods. They showed a significant increase in self-efficacy at immediate follow-up, but the change did not hold at the later follow-up. Compared to controls, intervention participants also were at significantly higher stages of change and a significantly higher percent had advanced their stage of change. However, although follow-up fat intake scores dropped considerably from baseline for both groups (about 24% for the intervention group and about 53% for the control group) the follow-up scores did not significantly differ between the two groups. Unexpectedly, the percentage reduction in the fat intake score of the control group was more than twice that of the intervention group. Finally, 79% of participants rated the program helpful and 66% said they would use it again while 55% said that none of the information was new to them.

Like the TLC studies, the StampSmart sample suffered from significant self-selection. Of the 2,046 initial contacts, only 378 were eligible, agreed to participate, and completed both baseline and follow-up surveys. In addition, the intervention was very low intensity at just one half hour. Finally, the fat intake results are puzzling. While the intervention group showed an increase in knowledge and stage of change compared to the control group, measured change in behavior was actually larger for the control group. This unexpected outcome may indicate a problem with the study design or the FFQ. Possibly the fact that baseline data from the intervention and control groups were collected using different modalities, computerized and in-person interview respectively, may have compromised the comparability of the data.

Campbell et al., 2004, looks at FoodSmart, a very similar tailored interactive PC program for the Special Supplemental Nutrition Program for Women, Infants and Children (WIC) participants in North Carolina. The sample included 307 adult respondents who completed the follow-up survey. Of these, 96% were female, 20% were pregnant and 50% were minorities. Especially high risk women, such as those with pregnancy complications, as designated by a WIC nutritionist, were excluded from the sample altogether because of the need for more intensive interpersonal counseling and follow-up. All pregnant and breastfeeding subjects must have had at least one prior counseling session with a WIC nutritionist. The participants were randomly assigned to control (n=166) and intervention (n=141) groups.

The FoodSmart intervention developed for this study was adapted from the StampSmart program evaluated by Campbell et al., 1999. FoodSmart included video soap opera, infomercial nutrition messaging and tailored feedback components similar to those included in the StampSmart program. The program ran approximately 30 to 40 minutes. FoodSmart focused on prenatal, infant and child nutrition and feeding and healthful food choices; increasing self-efficacy for changing behavior; and improving adult diets by lowering fat and increasing fruit and vegetable intake.

As in Campbell et al., 1999, intervention and control participants completed a baseline survey; however, unlike the previous study, both groups completed the surveys using the same modality, a computer. Yet, at follow-up, surveys were collected using different modalities, computer (intervention) and telephone (control) interviews. Intervention participants completed an immediate post-test survey and then all participants completed a one to two month follow-up. Control participants were allowed to use the intervention program after the final follow-up. Measures were also adapted from the StampSmart evaluation. The measures differed in that the FFQ and the knowledge and stage of change questions covered additional areas and self-efficacy was measured using five items instead of a single item.

When comparing the intervention group to the control group, after controlling for baseline differences, low-fat and infant feeding knowledge were significantly higher. Immediately after using the program, the intervention group showed statistically significant increases in self-efficacy overall and in the areas of low-fat dairy foods, low-fat snacks, cutting meat fat, eating fruits and vegetables, but not in baking instead of frying. Only the increase in efficacy for low-fat dairy foods remained significant in the one to two month follow-up. While both controls and participants showed advancement in stage of change, no intervention effect was seen. No intervention effect was seen in fat or fruit and vegetable consumption either. Finally, 64% of intervention participants reported that they found the program helpful, 87% said they would be interested in using a similar program later, and 51% felt that the program was too long.

The results of Campbell et al., 2004, are similar to those of Campbell et al., 1999. Both studies show significant increases in knowledge, increases in self efficacy immediately after completion of the program (though these changes did not persist), and no change in behavior. The authors suggest that the failure to impact behavior may be due to the low-intensity and dose of the education and potentially limited motivation among participants due to their low education levels, youth, and relative poverty. The study suffered from similar problems as did Campbell et al., 1999, including significant self-selection, and inconsistency in how data were captured (in this case, it was follow-up rather than baseline data that was captured using different modalities.)

The next study (Irvine et al., 2004) evaluated the use of an interactive multimedia computer program to encourage changes in fat and fruit and vegetable intake at two worksites. The program was designed with assumptions based on the Transtheoretical Model's stages of change in mind (Prochaska and Velicer, 1997). The stages of change include precontemplation, contemplation, preparation, action, and maintenance. The authors presumed that individuals would select program options depending upon their stage of change. The program included elements that targeted users' stages of change, attitudes, intentions, and self-efficacy. The program included recommendations for small steps toward success, testimonials of success, vignettes describing positive attitudes towards dietary behavior, positive self-efficacy messages, and opportunities for users to commit to changes.

To start, recruits were mailed an information packet, a questionnaire, a prepaid return mailer and a $10 incentive. Based on the questionnaire data, subjects were paired and randomly assigned to an intervention or wait-listed control group. Subjects accessed the computer program on one of three computers located at a private workstation set up for the study. Subjects were allowed 30 days to use the program and were encouraged to use it as often as they liked. One month after the intervention subjects completed the program, each subject-control pair was sent a follow-up questionnaire with an additional $10 and mailer. The wait listed group acted as a control to the intervention group for the baseline and one-month follow-up survey. After the follow-up was completed, the wait-listed control group was allowed to access the program. Each group received a third questionnaire package with a mailer and $10 one month after the follow-up survey for the initial users and one month following program use for the wait-listed group. The sample included 517 employees from one hospital (n=229) and one corporate worksite (n=288), of whom 85% were Caucasian, 73% female, 90% college educated, 86% full-time, and just 3.5% low income (family income < $20,000 per year). Of the 517 people who completed baseline surveys, 484 (94%) completed the second survey, and 463 (90%) completed the third.

The program included six main menu areas: eating strategies, recipes, barriers to healthy eating, eating habits assessment, information center and quick tips. Each area had up to six layers of interactive content. Figure 1 demonstrates an example of the many unique paths that one may follow after choosing the *eating strategies* menu.

Figure 1: Unique Path Through Layered Content

Level 1: **Eating strategies** – Recipes – Barriers to healthy eating– Eating habits assessment– Information center– Quick tips

↘

Level 2: **Adding fruits, vegetables and fiber**– Making low-fat food choices– Reducing fats as flavorings– modifying meat use

↘

Level 3: **At home**– At work– Eating out

↘

Level 4: **Shopping**– Food preparation– At the table– Snacks

↘

Level 5: **Buying low-fat**–Purchasing strategies

↘

Level 6: **Tailored Content: Narrated graphics and text, testimonials, and modeling vignettes**

Program content was also tailored by gender, personal interests, race and age. Because the program was interactive, multi-layered and tailored, there were millions of unique program combinations available to the user. The most commonly used eating strategy pathways included adding fruits, vegetables and fiber (42% of all pathway visits); making low-fat food choices (25%); reducing fats and flavoring (17%); and, modifying meat use (15%).

Outcome measures included fat-related eating behaviors based on a diet habits questionnaire (DHQ), fruit and vegetable consumption assessed using an FFQ, and performance of recommended behaviors. Measures of mediating factors included stage of change with respect to adopting a low-fat diet based on a five item instrument, and a small number of items on attitudes, intentions, and self-efficacy. On average, initial subjects used the program a total of 35 minutes and wait-list subjects used it 32 minutes for the first time. Only 15% of the initial group and 12% of the wait-list group used it a second time and 8% and 2%, respectively, used it a third time. Notably, intervention effects were consistent as all outcome and mediating factor measures changed in the desired direction and the changes were significantly greater for the treatment vs. the control group at the one-month follow-up and were maintained at the two-month follow-up. Impressively, this program obtained significant results with no personal contacts and minimal exposure to the program.

This study is limited by the use of solely self-reported behavior and the relative shortness of the follow-up period. Authors suggest additional research that involves measures of observed behavior and longer follow-up periods. In addition, the sample was fairly homogenous, largely comprised of college-educated, female, Caucasian subjects. Clearly, this program was much more successful than the interactive programs used by Campbell et al. (1999, 2004) among the poor, largely minority Food Stamp and WIC populations. A study of this interactive program in a population with different socio-demographic characteristics and different levels of personal motivation and sense of self-efficacy would expand our understanding of what type of tailored interactive interventions are likely to succeed among subgroups of people and the importance of personal characteristics such as self-efficacy and motivation in determining the usefulness of the intervention. As suggested by Campbell et al., 2004, the difference between impacts of any intervention on poorer, less educated versus wealthier, more educated groups may be due more to personal characteristics than to type of intervention conducted.

Web-Based Intervention

The last study in this review examines the feasibility and acceptability of a web-based nutrition education intervention. Oenema et al., 2001, was the first and, we believe, is the only study published by 2005 concerning interactive web-based tailored nutrition education. This study aimed to examine the potential effectiveness of the intervention before web distribution. However, the study was conducted in a highly controlled environment that did not approximate the internet environment that the intervention was designed for. Users were instructed to follow a certain sequence, rather than browse the site at will and were not allowed to browse outside of the website. Nonetheless, the format was a website and the subjects were apprised of that fact.

The self-selected sample was recruited from adult educational institutions in the Netherlands and randomly assigned to comparison and intervention groups. The final sample included 96 comparison and 102 intervention subjects, aged 44 years on average, of whom 62% were female and 47% were college educated. At baseline, 54% of the intervention and 43% of the comparison subjects exceeded recommended fat intakes, and 52% in both groups did not meet recommended fruit and vegetable intakes.

The theory underpinning the intervention is Weinstein's Precaution Adoption Process model (Weinstein, 1988) in which awareness of risky behavior proceeds through 3 stages: having heard of the risk associated with a particular behavior; awareness that others engage in the risky behavior; and acknowledgement of personally engaging in the risky behavior. The intervention focused on raising awareness of fat, fruit and vegetable intake and on intentions concerning consumption. Intervention messages were tailored to stage of change, attitudes and self-efficacy. The program provided feedback on user food intake and relevant recommendations, tips and recipes.

All participants completed a baseline and post-test assessment. The comparison group used paper and pencil while the intervention group completed it on-line. The on-line assessment was used as a diagnostic and tailoring tool for the intervention. The comparison group was exposed to general, non-tailored, written nutrition information pertaining to healthy diets, fat, and fruits and vegetables.

The study found that intervention subjects were significantly less likely to rate their fat intake as better than others and more likely to rate their fruit intake as better. They also showed a significantly stronger intention to eat less fat. Among those that did not meet dietary recommendations, intervention subjects were significantly more likely to rate their fat and vegetable intake as worse than others and to intend to eat more fruits and vegetables. Intervention subjects were significantly more likely to change their opinions about their diets as well as their intent to change. While all subjects felt that the information was clear, credible and interesting, intervention subjects were significantly more likely to rate the information as personally relevant for all three topics and to say that they would use the information again.

Like the other studies, this study suffers from self-selection bias. It also is limited by the lack of a follow-up survey beyond the immediate post-test survey and a fairly heterogeneous sample. Finally, this study did not test the program in an internet environment, making it more similar to a PC-based intervention than a web-based intervention.

Conclusions

While this small set of studies does not allow for strong conclusions, it offers us some clear direction for future research into interactive computer-tailored nutrition education.

Interactive computer-tailored interventions appear to be more successful among educated, employed, higher-income subjects. The StampSmart and FoodSmart studies (Campbell et al., 1999; Campbell et al., 2004) that were conducted among lower-income, less-educated subjects in food assistance offices did not demonstrate any impact with respect to behavior. Meanwhile, the studies (Glanz et al., 2003; Delichatsios et al., 2001; Irvine et al. 2004; Oenema et al. 2001) conducted among higher income and more educated, employed and/or insured persons demonstrated some impact with respect to behavior and intentions, although results were mixed. We cannot determine from this limited set of studies whether demographic characteristics or personal characteristics such as motivation and sense of self-efficacy associated with demographics influence intervention effectiveness most.

We also cannot differentiate between the impact of message content and the impact of the intervention mode (i.e., personal computer, phone, website, or multi-media production) because none of the studies compared intervention treatments using similar message content in two different modes.

More research needs to be conducted to determine what types of interactive computer-tailored interventions work best with what types of people. Do interventions work differently among people with varying levels of education, income and cultural backgrounds? Do people of different backgrounds tend to demonstrate different levels of self-efficacy and motivation which must be taken into account in designing interventions? Studies should be done that compare two or more types of interactive interventions in a single heterogeneous sample in order to sort out the effect of interactive mode and content from the impact of sample demographics and personal characteristics.

This review also raises the question of whether these interventions would be more successful at a higher intensity or dosage. Many interventions presented in the literature are so limited in exposure and dose that it is not reasonable to expect to find behavior impacts. Only two studies (Delichatsios et al., 2001; Irvine et al., 2004) reviewed here allowed subjects unlimited access to the program and only Delichatsios et al. (2001) tested differences in outcomes based on intensity of program use. They found a positive correlation between intensity of program use and outcome measures, but did not investigate whether the relationship was due to greater exposure to the program or to higher motivation among participants who chose to access the program more. More study interventions should be designed so that participants have enough exposure to the intervention to at least support an expectation of a lasting impact.

Finally, this review reveals two serious limitations in study design across the board, self-selection and reliance on self-reported outcome measures. Brug et al., 2003, in their review of computer tailoring research note that self-selection results in samples that tend to be overwhelmingly female, more educated, higher income and more highly motivated to change. The problem of self-selection is difficult to correct. Researchers need to make an extra effort to recruit men and less educated, and lower income people. In a review of earlier computer tailoring research, Brug et al. (1999) noted that the use of self-reported measures results in less-reliable, subjective, and biased measurements. The problem of self-reported measures persists in the studies reviewed here and elsewhere in nutrition education research. Nutrition education research would be greatly improved by the use of objective measures of dietary quality in studies with intervention doses and intensity that could reasonably be expected to change dietary outcomes over the study period. In such an environment, objective measures taken at baseline and after a significant follow-up period, such as behavioral observations or physiological indicators could be used to validate self-reported measures or stand alone as outcome measures.

Despite the limitations of these studies, we can conclude that interactive computer tailoring is a promising tool for nutrition education. Because interactive computer tailoring can reach multitudes of people simultaneously, its potential to help people progress through the stages of change and ultimately change behavior is far-reaching. To enhance the usefulness of interactive tailoring, much work remains to be done. Research that compares types of interventions within sample populations, tests intensity and dosage, corrects for self-selection and utilizes objective outcome measures may pave the way to a potential breakthrough in interactive computer-tailored nutrition education.

Bibliography

Brug, J., Campbell, M., and Van Assema, P. 1999. "The application and impact of computer-generated personalized nutrition education: a review of the literature." In *Patient Education and Counseling*. Vol. 36(2):145-156.

Brug, J., Oenema, A.M. and Campbell, M. 2003. "Past, present and future of computer- tailored nutrition education: a review of the literature." In *American Journal of Clinical Nutrition*. Vol. 77(Suppl):1028S-1034S.

Campbell, M., Honess-Morreale, L., Farrell, D., Carbone, E., and Brasure, M. 1999. "A tailored multimedia nutrition education pilot program for low-income women receiving food assistance." In *Health Education Research*. Vol. 14(2):257-267.

Campbell, M., Carbone, E., Honess-Morreale, L., Heisler-Mackinnon J., Demissie, S. L., and Farrell, D. 2004. "Randomized trial of a tailored nutrition education cd-rom program for women receiving food assistance." In *Journal of Nutrition Education and Behavior*. Vol. 36(2):58-66.

Delichatsios, H.K., Friedman, R.H., Glanz, K., Tennstedt, S., Smigelski, C., and Pinto, B. M. 2001. "Randomized trial of a "talking computer" to improve adults' eating habits." In *American Journal of Health Promotion*. Vol. 15(4):215-24.

Glanz, K., Shigaki, D., Farzanfar, R., Pinto, B., Kaplan, B., and Friedman, R.H. 2003. "Participant reactions to a computerized telephone system for nutrition and exercise counseling." In *Patient Education and Counseling*. Vol. 49(2):157-163.

Irvine, A.B., Ary, D.V., Grove, D.A., and Gilfillan-Morton, L. 2004. "The effectiveness of an interactive multimedia program to influence eating habits." In *Health Education Research*. Vol. 19(3):290-305.

Kreuter, M.W., Strecher, V.J., and Glassman, B. 1999. "One size does not fit all: the case for tailoring print materials." In *Annals of Behavioral Medicine*. Vol. 21(4):276-283.

Oenema, A., Brug, J. and Lechner, L. 2001. "Web-based tailored nutrition education: results of a randomized clinical trial." In *Health Education Research*. Vol. 16(6):647-660.

Perry, C.F. and Bauer, K.D. 2001. "Effect of Print Tailored Messaging on Cancer Risk Behavior." In *Topics in Clinical Nutrition*. Vol. 16(2):42-52.

Petty, R. and Cacioppo, J. 1986. "The Elaboration Likelihood Model of persuasion." In *Advances in experimental social psychology.* Vol. 19:123-205.

Prochaska, J.O. and Velicer, W.F. 1997. "The transtheoretical model of health behavior change." In *American Journal of Health Promotion*. Vol. 12(1):38-48.

Skinner, C.S., Campbell, M.K., Rimer, B.K., Curry, S., and Prochaska, J.O. 1999. "How effective is tailored print communication?" In Annals of Behavioral Medicine. Vol. 21(4):290-298.

Weinstein, N.D. 1988. "The precaution adoption process." In *Health Psychology*. Vol. 7(4):355-386.