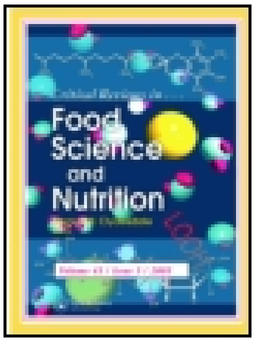

Critical Reviews in Food Science and Nutrition

ISSN: 1040-8398 (Print) 1549-7852 (Online) Journal homepage: http://www.tandfonline.com/loi/bfsn20

Visualized nutrition education and dietary behavioral change: A systematic review and meta-analysis

Xinyi Li, Yangmu Huang, Ruoyu Yin, Chenyu Pan, Yan Cai & Zhaokun Wang

To cite this article: Xinyi Li, Yangmu Huang, Ruoyu Yin, Chenyu Pan, Yan Cai & Zhaokun Wang (2018): Visualized nutrition education and dietary behavioral change: A systematic review and meta-analysis, Critical Reviews in Food Science and Nutrition, DOI: 10.1080/10408398.2018.1469466

To link to this article: https://doi.org/10.1080/10408398.2018.1469466

Accepted author version posted online: 04 May 2018.

Publisher: Taylor & Francis

Journal: *Critical Reviews in Food Science and Nutrition*

DOI: https://doi.org/10.1080/10408398.2018.1469466

Publisher: Taylor & Francis

Journal: *Critical Reviews in Food Science and Nutrition*

DOI: https://doi.org/10.1080/10408398.2018.1469466

Visualized nutrition education and dietary behavioral change: A systematic review and meta-analysis

Xinyi Li[1,#], Yangmu Huang[1,#,*], Ruoyu Yin[2], Chenyu Pan[2], Yan Cai[3], Zhaokun Wang[1]

[1] School of Public Health, Peking University Health Science Center, 38 Xueyuan Road, Beijing 100191, China.

[2] Institute for Medical Humanities, Peking University Health Science Center, 38 Xueyuan Road, Beijing 100191, China.

[3] School of Nursing, Peking University Health Science Center, 38 Xueyuan Road, Beijing 100191, China.

*Corresponding to

Yangmu Huang E-mail: ymhuang@bjmu.edu.cn.

[#]These two authors contributed equally to this work.

Abstract

Background: Effectiveness of using visual approaches in health education and its influential factors were still in debate. **Objectives**: To assess the effects of visualized nutrition education on dietary knowledge and behavioral changes, and factors influencing them. **Methods**: A comprehensive search of PubMed, EMBASE, Scopus and Cochrane Library was conducted. Eligible studies were trials assessed effects of visualized nutrition education on dietary knowledge or behavior changes, compared with non-visualized or no education group. **Results**: Fourteen studies (n=7,259) were qualitatively analyzed and 7 of them were included in the meta-analysis. We found a higher fiber intake in both short term (1.59g/1000kcals, 95%CI 0.90-2.27) and long term (1.36g/1000kcals, 95%CI 0.64-2.09). A marginal advantage was shown in short-term fruits and vegetables consumption (F&V consumption) (standardized mean difference (SMD) =0.08, 95%CI -0.00-0.16). The education effects were more pronounced when education was delivered in series

($SMD_{F\&V\ consumption}$=0.09, 95%CI 0.00-0.17), avoiding loss-framing ($SMD_{Fat\ intake}$=0.31, 95%CI 0.10-0.51) and video modeling ($SMD_{F\&V\ consumption}$=0.23, 95%CI 0.03-0.43), with short length plus cultural adaptation. **Conclusions**: Visualized nutrition education was overall promising in improving dietary behaviors. Delivering in series, short in length, with cultural adaptation were features tended to enlarge the benefits of visualized education while loss-framing and video modeling might be avoided.

Key words

visualized education; nutrition; behavioral change; meta-analysis

Introduction

Nutrition has substantial impact on health. In 2016, suboptimal diet was the second-leading risk factor for deaths and disability adjusted life years (DALYs) worldwide, accounting for 18.8% of all deaths and 9.6% of all DALYs, with metabolic risk factors closely related to nutrition such as high BMI, high cholesterol, and high blood glucose accounting for 16.8% of all DALYs (GBD 2016 Risk Factors Collaborators, 2017).

Large amount of studies have shown the effects of nutrition education on subsequent change of dietary knowledge and behaviors, especially for vulnerable population (Adamson & Mathers, 2004; Kroeze et al., 2006; Okorodudu et al., 2015;

Mosdøl et al., 2017; Murimi et al., 2017). However, relatively few studies have focused on visualized education, defined as applying multimedia techniques to present education information in visual forms, for example, video, picture, poster, to facilitate understanding of messages (Lin et al, 2014). The use of visualized medium in health education provides several potential advantages. First, visualized education does not require a high level of reading skill as written material does. A report showed that 23% of the English-speaking and 34% of the Spanish-speaking population in the U.S. could not adequately comprehend medical information in their spoken languages, with particularly high prevalence among ethnic minorities, low income and low education groups (Gazmararian et al., 1999). Besides, visualized intervention is less resource intensive. For instance, a video-based education program could result in annual savings of US $5,544,408 for 10,000 HIV patients (Sweat et al., 2001), not to mention pictures and posters which cost much less in development. In addition, visualized education can deliver more standardized intervention by removing inconsistencies across educators in traditional lecture-oriented methods (Gagliano, 1988), and reach broad audiences when combined with Internet and social network (Backinger et al., 2011).

Previous researches have explored the efficacy of individual type of visualized education such as video (Gagliano, 1988; Tuong et al., 2014) and picture (Houts et al., 2006; Barros et al., 2014). Some studies also investigated into effects of single influential factor like tailored (derived from individual assessment and reach one specific person) versus generic intervention (based on group characteristics and reach the general population) (Noar et al, 2007; Eyles & Mhurchu, 2009), gain-framing (focusing on advantages of compliance with recommended behaviors) versus loss-framing (emphasizing on disadvantages of non-compliance) (O'Keefe, 2009) and video modeling (active and visual demonstrations of desired behaviors) (Krouse, 2001). However, no studies have explored the effects of overall visualized education or have investigated a wide variety of influential factors.

The aim of the current review was to evaluate the effects of visualized nutrition education on change of dietary knowledge and behaviors, compared with non-visualized or no education, among general population, and to assess various factors' impact on education effects, in order to provide support for future development of visualized nutrition intervention.

Methods

We followed the reporting standards for systematic reviews and meta-analyses of randomized controlled trials according to the PRISMA statements (Moher et al., 2009).

Selection of studies

Studies were regarded as eligible if they 1) assessed the effect of visualized methods including video, picture, poster and leaflet or booklet with pictures as the main body and a least amount of texts in nutrition education; 2) compared the effect with non-visualized or no education as the parallel control group; 3) measured knowledge or diet-related behaviors, such as knowledge questionnaire scores, breast feeding frequency, fruits and vegetables consumption as outcomes. Studies consisting of both visualized and non-visualized interventions were excluded, unless the differences between intervention and control group were restricted to visualized components. Reviews, conference abstracts, qualitative studies, observational studies, and interventional studies using a pre- and post- control alone were also excluded.

Data sources and search strategy

Databases including PubMed, EMBASE, Scopus and Cochrane Library were searched from inception to June 2017 to identify relevant studies published in English. The following search strategy was run across in PubMed and tailored to each database when necessary: (visualiz* OR visual aid*OR visual-aid* OR audiovisual OR audio-visual OR multimedia OR multi-media OR film OR movie OR video OR videotape OR video-based OR poster OR picture OR photo OR photograph OR pamphlet OR booklet OR brochure OR leaflet) [Title/Abstract] AND (nutrition OR food OR food intake OR diet OR dietary OR dietary intake OR eating) [Title/Abstract] AND (health education OR health communication OR health promotion OR health behavior OR behavior change)[Title/Abstract]. In addition, reference lists from articles found through the database searches were hand-searched for potentially relevant publications.

Data extraction and quality assessment

Pairs of independent reviewers screened the title and the abstract of each study prior to full text screening of candidate studies. Any discrepancies in terms of the decision to a given study were dealt though discussion, if necessary, arbitration by a third reviewer. For all included studies, two reviewers independently extracted information on: setting, participants, intervention and control, duration of follow-up and results.

Studies quality were assessed using the Cochrane risk of bias assessment tool (Higgins et al., 2011) with the following criteria: generation of randomization sequence, allocation concealment, comparable groups at baseline, blinding of participants, researchers and outcome assessors, incomplete outcome data and other bias. Then a summary "risk of bias" score (high, unclear, low) was assigned to each study.

Data synthesis and analysis

Pre- and post- changes of each outcome was combined in meta-analysis, with standardized mean difference (SMD) or weighted mean difference (WMD) and 95% confidence interval (95%CI) reported. Statistical heterogeneity between studies was determined using the Cochrane χ^2 test and the I^2 statistic. A random effects model was used if heterogeneity was present, indicated by $p<0.1$ in χ^2 test and an $I^2>50\%$ (Higgins & Green, 2013), otherwise the fixed effects model was applied.

Sensitivity analysis was completed to detect the robustness of the statistical results and analyze possible sources of heterogeneity, using an alternative summary statistic (standardized versus weighted mean difference), or statistical model (fixed versus random effects model), and excluding studies one by one or those with high risk of bias.

When adequate studies ensuring the power of tests, Funnel plots and Egger's test were conducted to examine publication bias. Subgroup analysis and univariable meta-regression, if possible, were performed to explore pre-specified factors' impact on education effects: the gender, ethnicity, literacy and income of participants, the type, theory, tailoring, framing and frequency of interventions, the feature of control group, as well as the measurement method of outcomes. We also run a post hoc multivariable meta-regression when necessary. All data were analyzed using Stata 14.0 and Cochrane Review Manager (RevMan) 5.3.

Results

Figure 1 illustrates the process of screening and selecting studies. 533 studies were identified through searching PubMed, EMBASE, Scopus and Cochrane Library and 8 studies were added from manual searching. After excluding duplicates and reviewing abstracts, 52 full-text articles were retrieved. 14 studies fulfilling the eligibility criteria were analyzed qualitatively (Anderson et al., 2001; Bohnert et al., 2011; Campbell et al., 1999; Campbell et al., 2004; Cox et al., 2003; Fitriana et al., 2015; Gans et al., 2015; Goodman et al., 2016; Jeffery et al., 1982; Risica et al., 2013; Scheinmann et al., 2010; Upton et al., 2013; Windham et al., 2014; Winett et al., 1997).

The 14 trials were diverse in their research methods and outcomes. Thus, we were only capable to perform quantitative synthesis for the three most common outcomes assessed in included studies: fruits and vegetables (F&V) consumption, fat intake and fiber intake. 7 articles with at least one of the three outcomes were included in the meta-analysis (Anderson et al., 2001; Bohnert et al., 2011; Campbell et al., 1999; Campbell et al., 2004; Cox et al., 2003; Gans et al., 2015; Winett et al., 1997).

Characteristics of Included Studies

Characteristics of participants and interventions of all 14 studies were summarized in Table 1. Participants were predominantly female, in middle age or elder, and received education beyond high school. Studies that were with female as the majority had higher percentage of significant favorable results compared with studies that were not (82% vs. 33%). All studies conducted in middle age or elder population (mean age ≥40 years old) showed improvement in dietary knowledge or behaviors, with similar high percentage of success observed in 20-30 years olds (86%), yet no studies found positive changes in adolescents.

Seven studies (n = 2,882 participants) included in the meta-analysis were randomized controlled trials conducted in the United States, with sample size varying from 16 to 2,525 (median 277). Three studies measured the outcomes twice with the longer follow-up around 6 months or more and thus were categorized into long-term effects (Anderson et al., 2001; Gans et al., 2015; Winett et al., 1997). Their effects after shorter follow-up (<6 months) together with the results from the other four studies (1 week to 4 months follow-up) (Bohnert et al., 2011; Campbell et al., 1999; Campbell et al., 2004; Cox et al., 2003) were categorized as short-term effects in this meta-analysis.

Quality of Included Studies

Overall, the risk of bias of the studies was unclear to high (Table 1). The most common problem was fail to report allocation concealment, blinding of participants, researchers and outcome assessors, probably unable to do so due to the health educational nature of the trials, which should be improved in the future. Other sources of bias included small sample size (Bohnert et al., 2011) and adjusting the allocation with participants' willingness (Cox et al., 2003).

The effect on fruits and vegetables consumption

Six trials (n=2,505) were included for the short-term effect of nutrition education on F&V consumption (Anderson et al., 2001; Bohnert et al., 2011; Campbell et al., 2004; Cox et al., 2003; Gans et al., 2015; Winett et al., 1997). There was marginal significant advantage of F&V consumption increase in visualized education group over non-visualized and no education group (SMD=0.08, 95%CI -0.00-0.16, p=0.05) (Figure 2-A). A fixed effects model was used as there was no significant heterogeneity (I^2=0%, p=0.53). Subgroup analysis produced positive results when video modeling was not used, given in series, and when outcomes were measured objectively (Table 2). No significant association was shown in univariable meta-regression. Significant results appeared when using an alternative summary statistic (WMD=0.32, 95%CI 0.02-0.62, p=0.04) or excluding the study Campbell et al., 2004 (SMD=0.09, 95%CI 0.01-0.17, p=0.04). Funnel plot and statistical test provided no evidence of publication bias (Figure 3, Egger's test p=0.18).

Three trials (n=2,089) measured its long-term effect (Anderson et al., 2001; Gans et al., 2015; Winett et al., 1997). Difference in F&V consumption increase between groups disappeared after follow-up more than six months (SMD=0.07, 95%CI -0.02-0.16, p=0.11) (Figure 2-B). A fixed effects model was used as heterogeneity was insignificant (I^2=36%, p=0.21). Sensitivity analysis found significant results when an alternative summary statistic was used (WMD=0.33, 95%CI 0.03-0.63, p=0.03) and when the study Gans et al., 2015 was excluded

(SMD=0.22, 95%CI 0.02-0.42, p=0.03). Analysis of publication bias and subgroup effects were not performed due to the limited number of studies.

The effect on fat intake

Six trials (n=2,866) evaluated the short-term effect of nutrition education on fat intake (Anderson et al., 2001; Campbell et al., 1999; Campbell et al., 2004; Cox et al., 2003; Gans et al., 2015; Winett et al., 1997). The difference in fat intake changes between short-term visualized intervention and control was not significant (SMD=-0.04, 95%CI -0.24-0.15, p=0.65) (Figure 4-A). Due to the high heterogeneity (I^2=79%, p=0.00), a random effects model was used. Subgroup analysis yielded significant results in favor of visualized education when objective measurements were used, but in favor of control group when the intervention was loss-framed and applied once (Table 2). Univariable meta-regression suggested an association between fat intake decrease and objective measurement method (β=0.47, 95%CI 0.25-0.91, p=0.04), and proportion of ethnic minorities (β=-0.69, 95%CI -1.34~-0.04, p=0.04). However, the latter one disappeared after adjusting the cultural adaptation (β=-0.61, 95%CI -1.29-0.07, p=0.07). Excluding the study with high risk of bias did not change the overall effects but resulted in remarkable decrease in heterogeneity. Funnel plot and statistical test indicated no evidence of publication bias (Figure 5, Egger's test p=0.78).

Three trials (n=2,089) measured its long-term effect (Anderson et al., 2001; Gans et al., 2015; Winett et al., 1997). Similarly, the difference was not significant (SMD=-0.15, 95%CI -0.35-0.05, p=0.14) (Figure 4-B). Due to the high heterogeneity (I^2=60%, p=0.08), a random effects model was used. When the study Gans et al., 2015 was excluded in the sensitivity analysis, the difference became significantly in favor of visualized group (SMD=-0.28, 95%CI -0.48~-0.08, p=0.01). Funnel plot and subgroup analysis were not performed because of the limited number of studies.

The effect on fiber intake

Three trials (n=475) measured the short-term effect of nutrition education on fiber intake (Anderson et al., 2001; Cox et al., 2003; Winett et al., 1997). Visualized education resulted in a higher increase in fiber intake as 1.59g/1000kcals (95%CI 0.90-2.27, p=0.00) than control (Figure 6-A). The heterogeneity was not significant (I^2=5%, p=0.35). Similar results were identified through sensitivity analysis. Analysis of publication bias and subgroup effects were not performed due to the limited number of studies.

Two of them assessed the long-term effect as well (Anderson et al., 2001; Winett et al., 1997). A higher increase in fiber intake as 1.36 g/1000kcals (95%CI 0.64-2.09, p=0.00) was also observed compared with non-visualized or no education (Figure 6-B). A fixed effects model was used as heterogeneity was insignificant

(I^2=0%, p=0.32). Sensitivity analysis produced similar results. Analysis of publication bias and subgroup effects were not performed as there were only two studies.

Discussion

This meta-analysis found that visualized nutrition education has better effects in increasing fiber intake in both short-term and long-term follow-up, and a marginal advantage in promoting short-term F&V consumption, compared with non-visualized or no education. These effects were especially pronounced when interventions were cultural adapted, short in length, delivered in series. On the contrary, loss-framing and video modeling tended to reduce or even reverse those effects.

Cultural adaptation such as gathering information and involvement of local people in design process probably played an important role, as it eliminated the negative association between ethnic minorities' proportion and education effects in regression. This might infer lack of relevant adaptation made the intervention mainly designed by Caucasian researchers incompatible with the cultural patterns, meanings and values of Asian, Hispanic, and African American audience. Thus the effects were less-than-ideal. Evidence from non-visualized interventions has also supported that culturally adapted health message or counselling led to better adherence to an encouraged behavioral change than a standard treatment (Nierkens et al., 2013; Attridge et al., 2014).

Our result suggested that shorter length videos could enhance the effects of visualized education, as positive results emerged when trials with relatively long length videos were excluded in sensitivity analysis (Campbell et al., 2004; Gans et al., 2015). Previous study has also indicated that audience preferred short video segments with simple message to support learning, because they were less time-consuming and clear on the point (Ramsay et al., 2012). On the contrary, long videos showed obvious inferiority in process evaluation. For example, a study reported over 70% participants have read most or all of the written materials, while only 55% completed watching three videos each lasted for an hour (Gans et al., 2015).

Moreover, delivering in series rather than once would strengthen the efficacy of visualized education. Serial intervention usually lasted longer and provided frequent contacts with participants, giving chances to multiple points of assessment. As a result, apart from the stage-of-change at a point, we could also tailor interventions based on the longitudinal behavioral change of the participant (Noar et al., 2007).

Visualized nutrition education exhibit larger benefits when outcomes were measured through objective methods, such as weighing or shopping receipts, than self-reported scales like FFQ. In contrast, previous study supposed self-reported measurement could overestimate impact of education due to social desirability and memory bias (Eyles & Mhurchu, 2009). Reducing this bias by calculating pre- and post- changes (assuming similar impacts at baseline and posttest) might partially account for less overestimation. However, we were unable to adequately explain the relative advantages shown in objective measurements and further studies are warranted.

It should be mentioned that effects manifested in the short term, either the pooled results of meta-analyses or multiple evaluation in individual studies, often disappeared in the long term. This finding was in line with Tuong et al., 2014 and Gagliano, 1988. A possible explanation was characteristics of cognition and complexity of behaviors impeded the long-term retention of knowledge and behavioral change, which required further investigations.

We identified two other factors might attenuate the effects of visualized education. One was loss-framing, or emphasis on disadvantages of noncompliance with recommendations. This finding accorded with better effects of gain-framing than loss-framing in Tuong et al., 2014. A hypothesis was loss-framed messages might arouse fear and alienate the audience, and thereby inhibit behavioral change (Ben-Sira, 1981).

The other was video modeling, contrary to earlier consensus on the benefits of video modeling strategy in health education (Gagliano, 1988; Krouse, 2001; Tuong et al., 2014). However, a crucial discrepancy between our study and previous ones was the absence of anxiety situations. The theoretical basis of video modeling was the Social Learning Theory, which suggested it could decrease anxiety and improve adaptation to stressful situations, and real evidence were all derived from clinical settings like cancer screening or pre-operative education. Because trials in our study focused on dietary behaviors and mostly conducted in non-clinical settings, absence of stressful situations, thus relative advantage of not using video modeling appeared.

To our knowledge, this is by far the first meta-analysis concentrated in effects of visualized nutrition education on diet behavioral change and assessed comprehensive influential factors. Our study also has some limitations. First, only seven studies were included in the meta-analysis, which might reduce the power of analyses and did not represent all types of dietary behaviors. However, since most studies used mixed interventions, strict selection of studies was necessary to identify the effects attributable to visualized components. Second, we did not estimate the absolute effect size of F&V consumption and fat intake. As they were measured with different tools, it was reasonable to choose the SMD. Replacing with WMD would not change or would only enlarge current effects. Finally, only including published articles written in English might lead to overestimation of the effects, yet funnel plots and Egger's tests showed no evidence of publication bias.

Future trials should conduct and report adequately in line with the Consolidated Standards for Reporting of Trials (CONSORT) (Moher et al., 2010), especially improving the allocation concealment, blinding procedures and defining primary ones among multiple outcomes. Further studies should consider to include more objective and validated measurements, such as BMI, waist circumference even biochemical indexes, so as to provide a more accurate assessment of education effects and also facilitate comparability across studies. Moreover, large trials with longer follow-up in the future can help to clarify the efficacy of video modeling in nutrition education as well as discuss the long-term knowledge and behavioral changes. Upon confirmation of the effects of visualized education among vulnerable groups, exploration into approaches promoting interventions' accessibility to them, and providing relevant policy and environment support would be very beneficial.

Conclusion

Visualized nutrition education has shown better effects on some dietary behaviors than non-visualized or no education among general population. Interventions with cultural adaptation and relatively short length, delivering in series, avoiding loss-framing and video modeling were indicated to enhance the benefits of visualized education. Additional large well-designed studies with long follow-up are needed to further investigate the impact of audience's literacy and the long-term efficacy of visualized education.

Source of Funding

This work was supported by the Peking University Youbo Program under Grant BMU20150504.

Disclosure of Interest

All authors declare that there are no conflicts of interest.

References

Adamson, A. J., and Mathers, J. C. (2004). Effecting dietary change. *Proc Nutr Soc.* ***63***: 537-547.

Anderson, E. S., Winett, R. A., Wojcik, J. R., Winett, S. G., and Bowden, T. (2001). A computerized social cognitive intervention for nutrition behavior: direct and mediated effects on fat, fiber, fruits, and vegetables, self-efficacy, and outcome expectations among food shoppers. *Annals of Behavioral Medicine.* ***23***: 88-100.

Attridge, M., Creamer, J., Ramsden, M., Cannings-John, R., and Hawthorne, K. (2014). Culturally appropriate health education for people in ethnic minority groups with type 2 diabetes mellitus. *Cochrane Database of Systematic Reviews.* ***9***: D6424.

Backinger, C. L., Pilsner, A. M., Augustson, E. M., Frydl, A., Phillips, T., and Rowden, J. (2011). YouTube as a source of quitting smoking information. *Tobacco Control*. ***20***: 119-122.

Barros, I. M., Alcântara, T. S., Mesquita, A. R., Santos, A. C., Paixão, F. P., and Jr, L. D. (2014). The use of pictograms in the health care: a literature review. *Res Social Adm Pharm*. ***10***: 704-719.

Ben-Sira, Z. (1981). Latent fear-arousing potential of fear-moderating and fear-neutral health promoting information. *Social Science & Medicine. Part E: Medical Psychology*. ***15***: 105-112.

Bohnert, A. M., Randall, E. T., Tharp, S., and Germann, J. (2011). The Development and Evaluation of a Portion Plate for Youth: A Pilot Study. *Journal of Nutrition Education and Behavior*. ***43***: 268-273.

Campbell, M. K., Carbone, E., Honessmorreale, L., Heislermackinnon, J., Demissie, S., and Farrell, D. (2004). Randomized trial of a tailored nutrition education CD-ROM program for women receiving food assistance. *Journal of Nutrition Education & Behavior*. ***36***: 58-66.

Campbell, M. K., Honessmorreale, L., Farrell, D., Carbone, E., and Brasure, M. (1999). A tailored multimedia nutrition education pilot program for low-income women receiving food assistance. *Health Educ Res*. ***14***: 257-267.

Cox, R. H., White, A. H., Gaylord, and C. K. (2003). A video lesson series is effective in changing the dietary intakes and food-related behaviors of low-income homemakers. *Journal of the American Dietetic Association.* ***103***: 1488.

Eyles, H. C., and Mhurchu, C. N. (2009). Does tailoring make a difference? A systematic review of the long-term effectiveness of tailored nutrition education for adults. *Nutrition Reviews.* ***67***: 464-480.

Fitriana, N., Madanijah, S., and Ekayanti, I. (2015). Analysis of Media Use in the Nutrition Education on Knowledge, Attitude and Practice of the Breakfast Habits on Elementary School Students. *Pakistan Journal of Nutrition.* ***14***: 335-345.

Gagliano, M. E. (1988). A Literature Review on the Efficacy of Video in Patient Education. *Journal of Medical Education.* ***63***: 785.

Gans, K. M., Risica, P. M., Dulinkeita, A., Mello, J., Dawood, M., Strolla, L. O., et al. (2015). Innovative video tailoring for dietary change: final results of the Good for you! cluster randomized trial. *International Journal of Behavioral Nutrition & Physical Activity.* ***12***: 130.

Gazmararian, J. A., Baker, D. W., Williams, M. V., Parker, R. M., Scott, T. L., Green, D. C., et al. (1999). Health literacy among Medicare enrollees in a managed care organization. *JAMA.* ***281***: 545-551.

GBD 2016 Risk Factors Collaborators. (2017). Global, regional, and national comparative risk assessment of 84 behavioural, environmental and occupational, and metabolic risks or clusters of risks, 1990-2016: a systematic analysis for the Global Burden of Disease Study 2016. *Lancet*. ***390***: 1345-1422.

Goodman, S., Morrongiello, B., and Meckling, K. (2016). A randomized, controlled trial evaluating the efficacy of an online intervention targeting vitamin D intake, knowledge and status among young adults. *International Journal of Behavioral Nutrition & Physical Activity*. ***13***: 116.

Higgins, J. P., Altman, D. G., Gotzsche, P. C., Juni, P., Moher, D., Oxman, A. D., et al. (2011). The Cochrane Collaboration's tool for assessing risk of bias in randomised trials. *BMJ*. **343**: d5928.

Higgins, J., and Green, S. (2013). Cochrane Handbook for Systematic Reviews of Interventions, Version 5.1.0. Available at: http://www.cochrane-handbook.org.

Houts, P. S., Doak, C. C., Doak, L. G., and Loscalzo, M. J. (2006). The role of pictures in improving health communication: A review of research on attention, comprehension, recall, and adherence. *Patient Education & Counseling*. ***61***: 173.

Jeffery, R. W., Pirie, P. L., Rosenthal, B. S., Gerber, W. M., and Murray, D. M. (1982). Nutrition education in supermarkets: An unsuccessful attempt to influence knowledge and product sales. *Journal of Behavioral Medicine*. ***5***: 189.

Kroeze, W., Werkman, A., and Brug, J. (2006). A systematic review of randomized trials on the effectiveness of computer-tailored education on physical activity and dietary behaviors. *Annals of Behavioral Medicine.* ***31***: 205.

Krouse, H. J. (2001). Video modelling to educate patients. *J Adv Nurs*. **33**: 748-757.

Lin, W. P., Liu, X. C., Yang, S. Q., and Chen, Y. (2014). Effect of visual health education on postoperative urinary retention in patients with cervical cancer. *Zhejiang Medical Education*. **13**: 36-38.

Moher, D., Hopewell, S., Schulz, K. F., Montori, V., Gøtzsche, P. C., Devereaux, P. J., et al. (2010). Consolidated Standards of Reporting Trials Group. CONSORT 2010 explanation and elaboration: updated guidelines for reporting parallel group randomised trials.

Moher, D., Liberati, A., Tetzlaff, J., and Altman, D. G. (2009). Preferred reporting items for systematic reviews and meta-analyses: the PRISMA statement. *BMJ.* ***339***: b2535.

Mosdøl, A., Lidal, I. B., Straumann, G. H., and Vist, G. E. (2017). Targeted mass media interventions promoting healthy behaviours to reduce risk of non-communicable diseases in adult, ethnic minorities. *Cochrane Database of Systematic Reviews.* **2**.

Murimi, M. W., Kanyi, M., Mupfudze, T., Amin, M. R., Mbogori, T., and Aldubayan, K. (2017). Factors Influencing Efficacy of Nutrition Education Interventions: A Systematic Review. *J Nutr Educ Behav.* ***49***: 142-165.

Nierkens, V., Hartman, M. A., Nicolaou, M., Vissenberg, C., Beune, E. J. A. J., Hosper, K., et al. (2013). Effectiveness of Cultural Adaptations of Interventions Aimed at Smoking Cessation, Diet, and/or Physical Activity in Ethnic Minorities. A Systematic Review. *Plos One.* ***8***: e73373.

Noar, S. M., Benac, C. N., and Harris, M. S. (2007). Does tailoring matter? Meta-analytic review of tailored print health behavior change interventions. *Psychol Bull.* ***133***: 673-693.

O'Keefe, D. J. (2009). The relative persuasiveness of gain-framed and loss-framed messages for encouraging disease prevention behaviors: a meta-analytic review. *Journal of Communication.* ***59***: 296-316.

Okorodudu, D. E., Bosworth, H. B., and Corsino, L. (2015). Innovative Interventions to Promote Behavioral Change in Overweight or Obese Individuals: A Review of the Literature. *Annals of Medicine.* ***47***: 179.

Ramsay, S. A., Holyoke, L., Branen, L. J., and Fletcher, J. (2012). Six Characteristics of Nutrition Education Videos That Support Learning and Motivation to Learn. *Journal of Nutrition Education & Behavior.* ***44***: 614-617.

Risica, P. M., Gans, K. M., Kumanyika, S., Kirtania, U., and Lasater, T. M. (2013). SisterTalk: final results of a culturally tailored cable television delivered weight control program for Black women. *International Journal of Behavioral Nutrition & Physical Activity*. ***10***: 141.

Scheinmann, R., Chiasson, M. A., Hartel, D., and Rosenberg, T. J. (2010). Evaluating a Bilingual Video to Improve Infant Feeding Knowledge and Behavior Among Immigrant Latina Mothers. *Journal of Community Health*. ***35***: 464-470.

Sweat, M., O'Donnell, C., and O'Donnell, L. (2001). Cost-effectiveness of a brief video-based HIV intervention for African American and Latino sexually transmitted disease clinic clients. *Aids*. ***15***: 781.

Tuong, W., Larsen, E. R., and Armstrong, A. W. (2014). Videos to influence: a systematic review of effectiveness of video-based education in modifying health behaviors. *J Behav Med*. ***37***: 218-233.

Upton, D., Upton, P., and Taylor, C. (2013). Increasing children's lunchtime consumption of fruit and vegetables: an evaluation of the Food Dudes programme. *Public Health Nutrition*. ***16***: 1066-1072.

Windham, M. E., Hastings, E. S., Anding, R., Hergenroeder, A. C., Escobarchaves, S. L., and Wiemann, C. M. (2014). "Teens Talk Healthy Weight": the impact of a motivational digital video disc on parental knowledge of obesity-related diseases in an adolescent clinic. *Journal of the Academy of Nutrition & Dietetics*. ***114***: 1611-1618.

Winett, R. A., Anderson, E. S., Bickley, P. G., Walberg-Rankin, J., Moore, J. F., Leahy, M., et al. (1997). Nutrition for a Lifetime System©: A multimedia system for altering food supermarket shoppers' purchases to meet nutritional guidelines. *Computers in Human Behavior*. **13**: 371-392.

Figure Legends

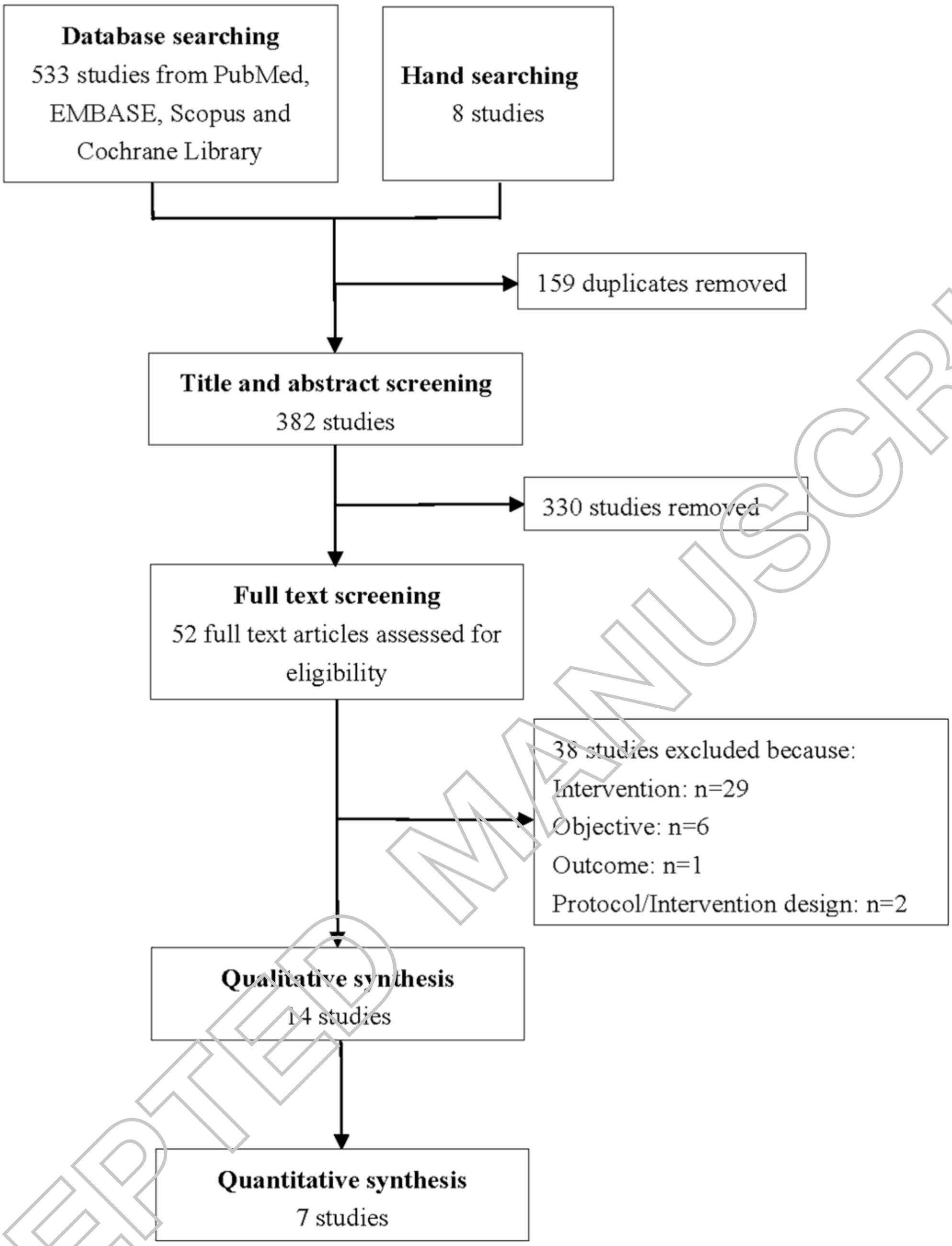

Figure 1. Flow diagram of search and selection of studies.

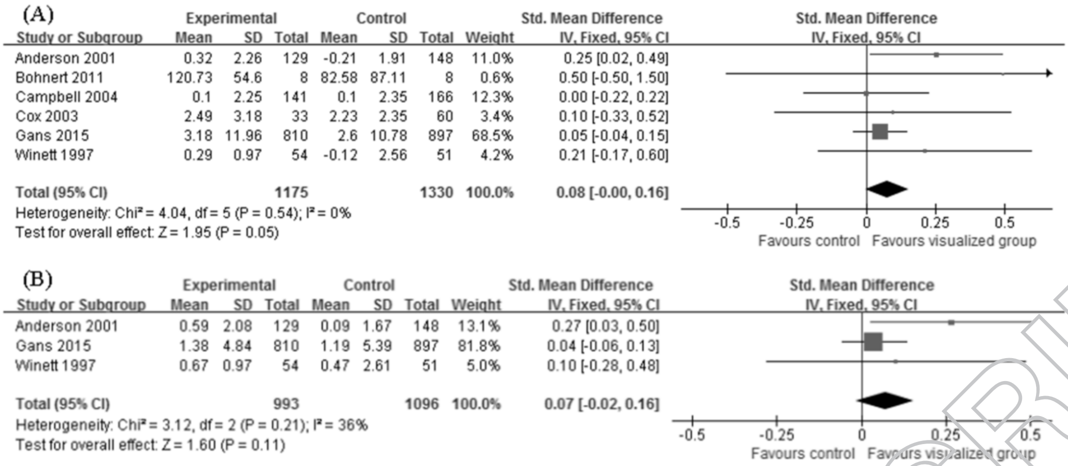

Figure 2. Short-term (A) and long-term (B) effects of visualized education on fruits and vegetables consumption.

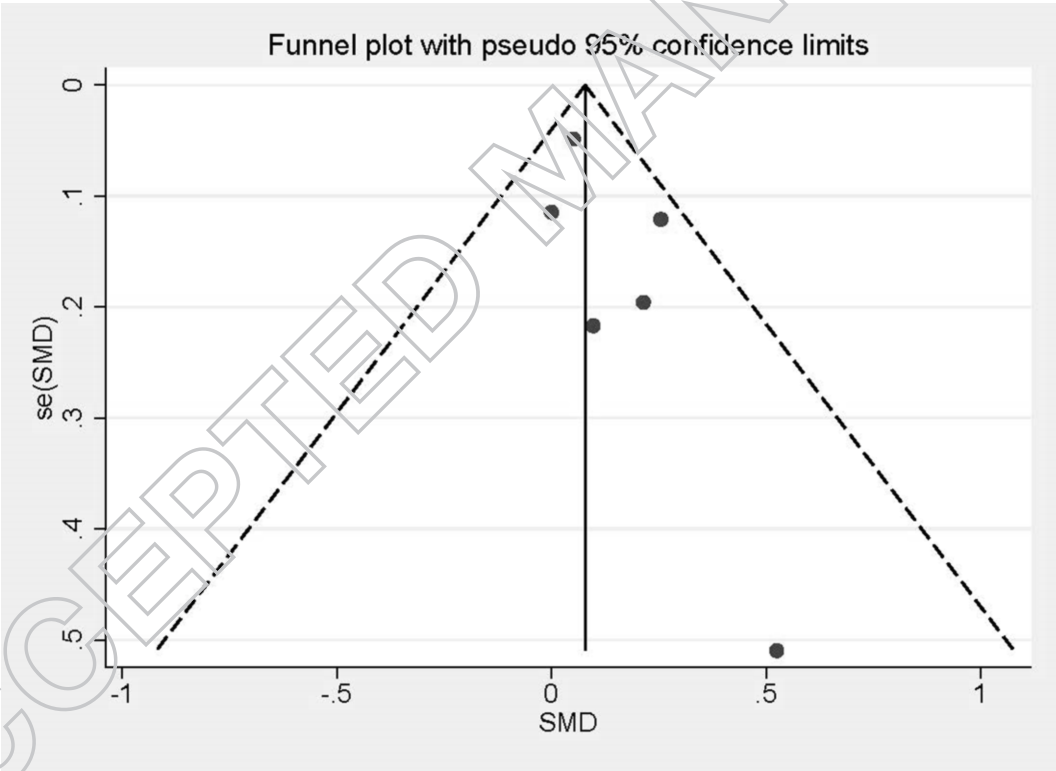

Figure 3. Funnel plot of studies reporting fruits and vegetables consumption.

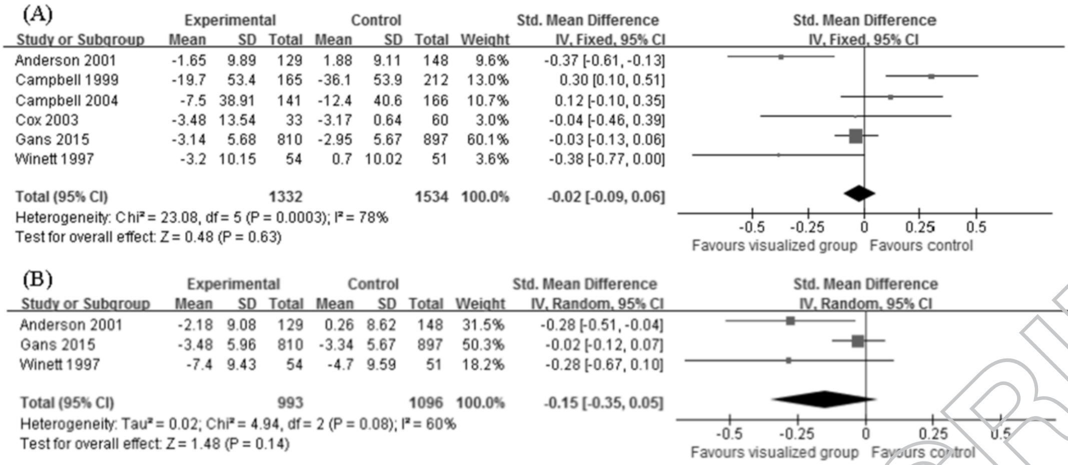

Figure 4. Short-term (A) and long-term (B) effects of visualized education on fat intake.

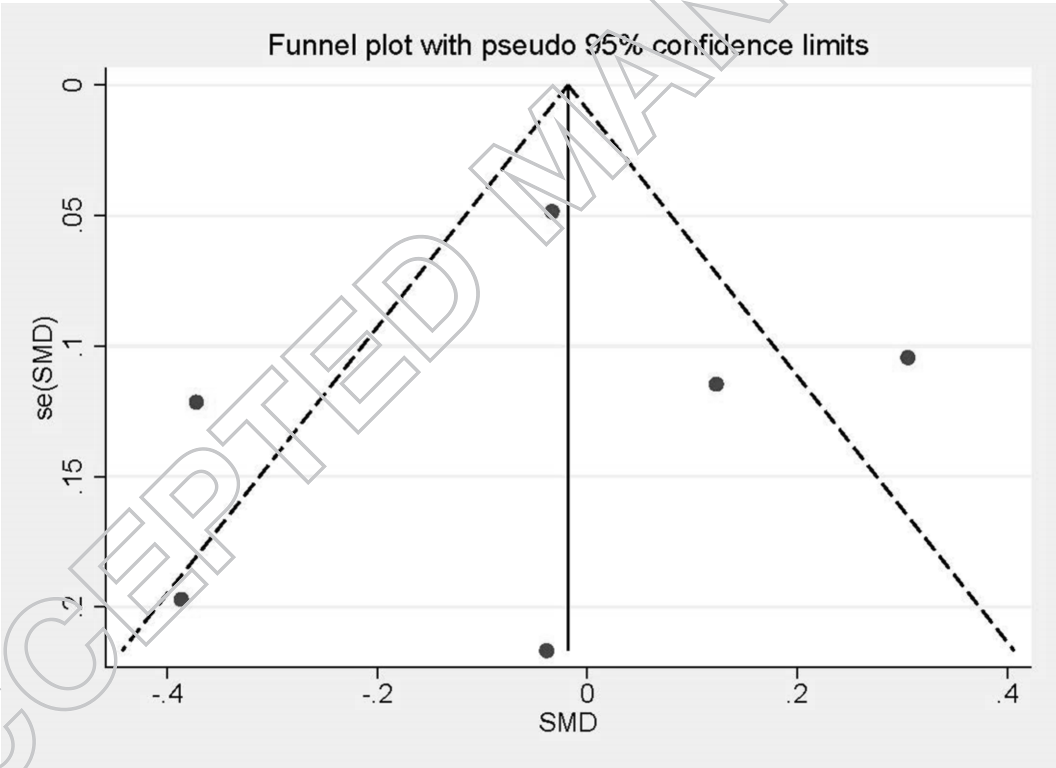

Figure 5. Funnel plot of studies reporting fat intake.

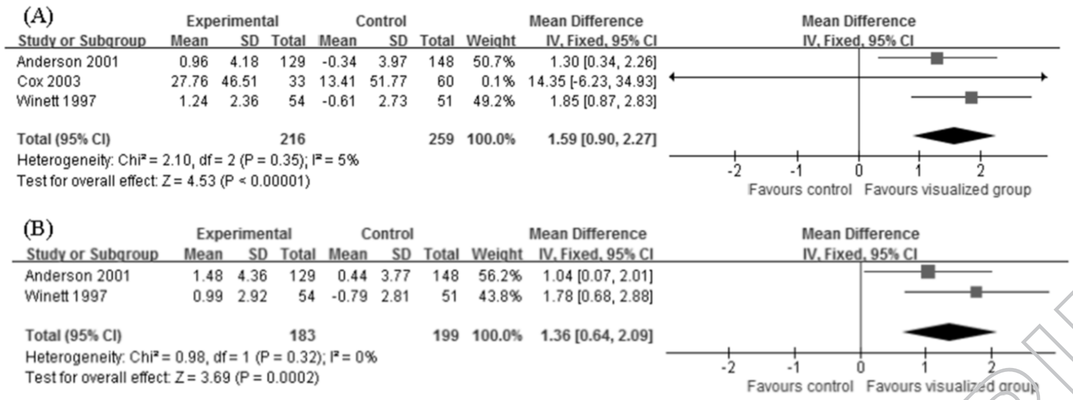

Figure 6. Short-term (A) and long-term (B) effects of visualized education on fiber intake.

Table 1. Characteristics of studies evaluating the effects of visualized nutrition education on dietary knowledge and behaviors.

First author (year), Country	Study population	Groups	Intervention feature	Follow-up	Outcomes	Measurement methods	Results	Overall risk of bias
Anderson E.S. (2001), USA	N=277, F/M=266/11, 92% White, 80% beyond high school graduation, 12% low income, recruited from supermarkets	T: video series (n=129); C: no education (n=148)	gain-framed, tailored according to personal goal, based on Social Cognitive Theory, strategies used: goal setting, self-regulation, rewards (coupons)	immediately	Fat intake (% calories)	shopping receipts	0	unclear
					Fiber intake (g/1000kcals)	shopping receipts	+	
					F&V consumption (servings/1000kcals)	shopping receipts	0	
				4-6 months	Fat intake (% calories)	shopping receipts	0	
					Fiber intake (g/1000kcals)	shopping receipts	0	
					F&V consumption (servings/1000kcals)	shopping receipts	0	
Bohnert A.M. (2011), USA	N=16, F/M=5/11, 12.94y, all African American, 54% low income family, 75% overweight or obese	T: visualized portion plate (n=8); C: plain plate (n=8)	gain-framed, generic, highly interactive (developed the plate by themselves)	1 week	Fruits consumption (g)	weighing	0	high
					Health food selected (%)	weighing	0	
Campbell M.K.	N=307, F/M=299/8, 27±8y,	T: soap opera	gain-framed, tailored	1-2 months	Low fat knowledge	questionnaire	+	unclear

(2004), USA	50% ethnic minorities, all low income, 81.1% beyond high school graduation, recruited at WIC clinics	(n=141); C: no education (n=166)	according to baseline knowledge and dietary intake, based on Social Cognitive Theory and Trans-theoretical Model, strategies used: video modeling, personalized feedback		Infant feeding knowledge Fat intake (g/day) F&V consumption (servings/day)	questionnaire FFQ FFQ	+ 0 0	
Campbell M.K. (1999), USA	N=378, 100%women, 29.3y, 85.3%African American, all low income (receiving food stamps), 30% beyond high school	T: soap opera (n=165); C: no education (n=212)	loss-framed, tailored according to stage of change and perceived weight concerns, based on Social Cognitive Theory, Trans-theoretical Model, strategies used: video modeling, interactive exercises with feedback, stage based behavioral messages and small steps to initiate action	1-3 months	Knowledge of low fat food Fat intake (g)	questionnaire FFQ	+ -	unclear
Cox R.H. (2003), USA	N=93, 100%women, 28±8y, 57%White, 43% African American, 47% not graduated from high school, all low income (received	T: video series (n=33); C: face-to-face sessions (n=60)	gain-framed, generic, with telephone discussion and home visits	3 months	Food safety, meal preparation and nutrition behaviors Fruits (servings/day)	PSBC 24-hr food recalls	0 -	high

	kinds of assistance)				Vegetables (servings/day)	24-hr food recalls	+	
					Fat intake (%kcal)	24-hr food recalls	0	
					Fiber (%DRI)	24-hr food recalls	+	
Fitriana N. (2015), Indonesia	N=166, F/M=89/77, 10-11y, mainly Asian, 5th-grade elementary school, 20.5% low income, recruited from schools	T1: poster, lecture, discussion (n=43);	loss-framed, generic, with lecture, discussion	1 month	T1:Breakfast knowledge	questionnaire	0	high
					Breakfast frequency	24-hr food recalls	0	
		T2: leaflet, lecture, discussion (n=40);			Nutritional quality	24-hr food recalls	0	
					T2:Breakfast knowledge	questionnaire	0	
		T3:multimedia, lecture, discussion (n=42);			Breakfast frequency	24-hr food recalls	0	
					Nutritional quality	24-hr food recalls	+	
		C:lecture,discussion (n=41)			T3:Breakfast knowledge	questionnaire	0	
					Breakfast frequency	24-hr food recalls	0	
					Nutritional quality	24-hr food recalls	0	
Gans K.M. (2015), USA	N=2525, F/M=2038/487, predominant 40-49y, 88.6%White, 83.2% beyond	T: Tailored video series + tailored written material (TV +	gain-framed, tailored according to baseline dietary intake and personal goals, strategies used:	4 months	Fat intake (%kcal)	NCI Fat Screener	0	unclear
					Fat-related behaviors	FHQ	+	

	high school graduation, 5% low income, recruited at worksite	TW)(n=810); C:Tailored written material (TW)(n=897)	video modeling		F&V consumption (servings)	NCI F&V screener assessment tool	0	
					F&V-related behaviors	FVHQ	+	
				8 months	Fat intake (% cal)	NCI Fat Screener	0	
					Fat-related behaviors	FHQ	0	
					F&V consumption (servings)	NCI F&V screener assessment tool	0	
					F&V-related behaviors	FVHQ	+	
Goodman S. (2016), Canada	N=90, F/M=:52/38, 22±2.0y, 51%White, 83% beyond high school	T: video series (n=41); C: no education (n=49)	loss-framed, generic, based on Theory of Planned Behavior, and Prototype Willingness Model, strategies used: personalized feedback, reminders, goal setting	3 months	VD knowledge	Vitamin D Survey	+	high
					VD intake (IU/day)	FFQ	+	
Jeffery R.W. (1982), USA	N=403, F/M=293/110, majority 20-39y, mainly White, 68.7% beyond high school graduation, recruited	T: posters (n=207); C: no education (n=196)	gain-framed, generic	10 months	Knowledge of fat content of foods	questionnaire	0	high

	at supermarkets							
Risica P.M. (2013), USA	N=154, 100%Women, majority 40-49y, 80% African American, 79% beyond high school graduation, 24% low income	T: TV program series, written materials (n=72); C:written materials (n=82)	gain-framed, generic, based on Social Action Theory, strategies used: video modeling	3 months 8 months 12 months	Fat-related behaviors Fat-related behaviors Fat-related behaviors	FHQ FHQ FHQ	+ + +	unclear
Scheinmann R. (2009), USA	N=272, 100% women, 29y, all Latina, 50% beyond high school graduation, low income	T: video (n=143); C: no education (n=129)	gain-framed, generic, derived from evaluation from the same population	6 months	Infant feeding knowledge Infant feeding behaviors	questionnaire questionnaire	+ +	high
Upton D. (2012), UK	N=2433,F/M=1147/1286, 4–11y, 50% ethnic minorities, primary school students, poor area	T: DVD episodes (n=1282); C:no education (n=1151)	gain-framed, generic, passive, strategies used: video modeling ，rewards	3 months 12 months	F&V consumption (g) F&V consumption (g)	weighing weighing	0 0	high
Windham M.E. (2014), USA	N=40, F/M=31/9, 15.43±1.76y, 72.5% Non-White, obesity	T: videos, standardized verbal and written nutrition education (n=21); C: standardized verbal	gain-framed, generic, passive, based on Social Cognitive Theory, strategies used: video modeling,	4-6 weeks	Obesity-related knowledge	questionnaire	0	unclear

		and written nutrition (n=19)	goal setting					
Winett R.A. (1997), USA	N=105, 86%Women, 40(19-77)y, 95%White, 87%beyond high school graduation, 28% low income, recruited at supermarkets	T: video series (n=54); C: no education (n=51)	gain-framed, generic, strategies used: video modeling, goal setting, rewards(coupons), with interactive questions	immediately	Fat (%calories)	shopping receipts	+	unclear
					Fiber (g/100kcals)	shopping receipts	+	
					F&V consumption (servings/1000kcals)	shopping receipts	0	
				6 months	Fat (%calories)	shopping receipts	0	
					Fiber (g/100kcals)	shopping receipts	0	
					F&V consumption (servings/1000kcals)	shopping receipts	0	

Abbreviations: +, in favor of visualized nutrition education; 0, no significant difference between groups; -, in favor of control; F, female; M: male; F&V: fruits and vegetables consumption; FFQ, Food Frequency Questionnaire; PSBC, Pennsylvania State Behavior Checklist; NCI, National Cancer Institute; FHQ, Food Habits Questionnaire; FVHQ, Fruit and Vegetable Habits Questionnaire

Table 2. Subgroup analysis for the short-term effects of visualized education on fruits and vegetables consumption and fat intake

	Fruit and vegetables consumption			Fat intake		
	SMD	95%CI	p	SMD	95%CI	p
Based on theory						
Yes	0.12	(-0.13，0.37)	0.33	0.02	(-0.37，0.41)	0.91
No	0.07	(-0.02，0.16)	0.15	-0.10	(-0.29，0.09)	0.30
Tailoring						
Tailored	0.08	(-0.04，0.20)	0.18	0.01	(-0.22，0.24)	0.94
Generic	0.19	(-0.09，0.46)	0.18	-0.22	(-0.57，0.12)	0.20
Video Modeling						
Yes	0.05	(-0.03，0.14)	0.23	0.04	(-0.18，0.25)	0.74
No	0.23	(0.03，0.43)	**0.03**	-0.25	(-0.57，0.06)	0.11
Frequency						
Once	0.03	(-0.20，0.26)	0.82	0.22	(0.04，0.40)	**0.02**
Series	0.09	(0.00，0.17)	**0.04**	-0.19	(-0.41，0.03)	0.09
Control group						
Blank	0.15	(-0.01，0.30)	0.06	-0.07	(-0.41，0.28)	0.71
Non-visualized	0.05	(-0.04，0.15)	0.26	-0.03	(-0.13，0.06)	0.48
Measurement						
Objective	0.26	(0.06，0.45)	**0.01**	-0.38	(-0.58，-0.17)	**0.00**
Self-reported	0.05	(-0.04，0.13)	0.30	0.10	(-0.09，0.28)	0.31
Type						
Video	0.08	(-0.00，0.16)	0.06	\	\	\
Plate	0.53	(-0.47，1.52)	0.30	\	\	\
Framing						
Gain-framed	\	\	\	-0.12	(-0.31，0.07)	0.21
Loss-framed	\	\	\	0.31	(0.10，0.51)	**0.00**

Bold, $p<0.05$; \, subgroup inapplicable to this outcome.