Recent population adherence to and knowledge of United States federal nutrition guides, 1992–2013: a systematic review

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Title: Recent Population Adherence to and Knowledge of United States Federal Nutrition Guides 1992-2013: A Systematic Review

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Abstract: The Dietary Guidelines for Americans dictate federal nutrition programs and policies. Corresponding nutrition guides have been established to guide the public in dietary intake patterns, as well as to ameliorate the US obesity epidemic and its health-related outcomes. The purpose of this systematic review was to summarize population adherence to and knowledge of United States nutrition guides since 1992, including Food Guide Pyramid, MyPyramid, and MyPlate. Of the 31 studies included for review, 22 examined adherence, six examined knowledge, and three examined both adherence and knowledge. Across studies, adherence to nutrition guides was low, with participants consuming inadequate levels of fruits, vegetables, and dairy in particular. Knowledge of nutrition guides increased over time since publication and decreased with age of participants. Association between knowledge of and adherence to nutrition guides was not found. Disparities in knowledge and adherence existed across demographic groups. Based on these findings, federal dietary guidance can be strengthened by increasing dissemination of nutrition guides to the public and tailoring promotional activities for demographic and socioeconomic groups.

Key words: Food Guide Pyramid, MyPyramid, MyPlate, adherence, knowledge

ABSTRACT

The Dietary Guidelines for Americans dictate federal nutrition programs and policies. Corresponding nutrition guides have been established to guide the public in dietary intake patterns, as well as to ameliorate the US obesity epidemic and its health-related outcomes. The purpose of this systematic review was to summarize population adherence to and knowledge of United States nutrition guides since 1992, including Food Guide Pyramid, MyPyramid, and MyPlate. Of the 31 studies included for review, 22 examined adherence, six examined knowledge, and three examined both adherence and knowledge. Across studies, adherence to nutrition guides was low, with participants consuming inadequate levels of fruits, vegetables, and dairy in particular. Knowledge of nutrition guides increased over time since publication and decreased with age of participants. Association between knowledge of and adherence to nutrition guides was not found. Disparities in knowledge and adherence existed across demographic groups. Based on these findings, federal dietary guidance can be strengthened by increasing dissemination of nutrition guides to the public and tailoring promotional activities for demographic and socioeconomic groups.

INTRODUCTION

As of 2012, 34.9% of US adults and 16.9% of US children were considered obese,[1] compared to 35.1% and 16.7% in 2010, respectively,[2,3] a reflection of a national diet high in empty calories, refined grains, and saturated fat.[4] Since the passage of the 1990 National Nutrition Monitoring and Related Research Act, the United States Department of Agriculture and Department of Health and Human Services have been charged with publishing Dietary Guidelines for Americans (DGA) once every five years in order to provide the public with nutrition information and guide federal nutrition programs.[5] These guidelines have evolved to

meet population needs in line with current research. DGA 2010, for example, addresses overweight, obesity, and chronic disease concerns, and emphasizes both individual and environmental factors as determinants of health outcomes.[6]

DGA have served as the inspiration and scientific basis for the development of nutrition guides, visually-based population tools for communicating nutrition information to the public.[7] Also reflecting the current national health status, nutrition research, and consumer needs, the Food Guide Pyramid (FGP) (1990),[8] MyPyramid (2005),[9] and MyPlate (2010)[10] have provided iconic representation of health promotion and education materials. FGP portrayed recommended food group servings as proportional segments within a pyramid shape, with the tip representing minimal intake of fats, oils, and sweets.[8] In 2005, MyPyramid accompanied DGA 2005.[9] MyPyramid replaced horizontal food group servings in the Food Guide Pyramid with vertical slices and incorporated an interactive online component to determine individualized food group and macronutrient recommendations, as well as an exercise component, with a human running up the side of the pyramid.[9] Next, MyPlate tracked with DGA 2010.[10] The pyramid shape was replaced with a plate and food groups represented a proportion of a meal instead of absolute serving sizes. MyPlate's rollout also focused heavily on nutrition education and total health.[6]

Nutrition guides are designed to influence public health.[11] Establishing the impact of these guides will assist nutrition educators, researchers, and policy makers in the development of evidence-based health promotion strategies. The purpose of this systematic review was to assess population adherence to and knowledge of United States (US) nutrition guides since 1992. Given the current dietary patterns of the US population and related health outcomes, poor adherence to and knowledge of nutrition guides is hypothesized.

METHODS

Knowledge of and adherence to nutrition guide recommendations were examined. In this review, knowledge refers to information known about nutrition guides or reported application of nutrition guides without measuring intake. Adherence refers to dietary intake of participants in terms of nutrition guide recommendations. Food group terminology has changed as nutrition guides have evolved, and for the purpose of this review, "grains" refers to FGP bread, cereal, rice, and pasta group as well as MyPyramid and MyPlate grains groups; "proteins" refers to FGP meat, poultry, fish, dry beans, eggs, and nuts group, MyPyramid meat and beans group, and MyPlate protein foods group; and "dairy" refers to FGP milk, yogurt, and cheese group. Fruit and vegetable groups were nominally the same.

Articles included in the review were gleaned through a systematic literature search of three electronic databases (PubMed, ScienceDirect, and Web of Knowledge). Terms used in this search included: *Food Guide Pyramid*, *MyPyramid, or MyPlate* and *adherence*, *follow*, *knowledge*, *compliance*, or *behavior*. Articles retrieved from initial search were screened using the following criteria: English language, conducted in the US, and published after 1992 until October 2013. The year 1992 was chosen as it marks the year the FGP was published.[9]

Articles fitting inclusion criteria were considered for full review if the title, abstract, or keywords indicated that the study examined adherence or consumption in relation to or knowledge of FGP, MyPyramid, MyPlate, or a combination of those terms. A list of non-duplicative relevant articles that met the inclusion criteria was compiled. The full texts of potentially relevant articles were reviewed for inclusion if they focused on knowledge of or adherence to nutrition guides. For example, studies describing intake patterns of macronutrients and micronutrients without mention of food groups or studies with categorizations of food groups not matching nutrition guides were excluded.[11,12] Studies focusing on one or two food

groups relative to a nutrition guide, such as just fruit and vegetable (FV) consumption, were included. Studies were excluded if they occurred outside of the US or presented dietary data not compared to US nutrition guidance. Studies reviewing additional federal dietary guidance (DGA, etc.) were included in the review as supplementary insight only if they met the inclusion criteria and relevance to nutrition guides. No studies were excluded or reviewed based on study design, sample, or study quality to allow for a variety of participant characteristics, methods, and variables.

A final list of relevant studies was compiled for full review, and a data matrix of these studies was generated by study authors using the following headings: first author, year; nutrition guide; purpose; measures; sample size, demographics; results.

RESULTS

The initial database search retrieved 2,514 articles, and 2,461 abstracts were screened after initial exclusion of 53 non-English articles and articles published before 1992 (See Figure 1). After elimination of those that did not pertain to adherence to or knowledge of FGP, MyPlate, or MyPyramid, 37 non-duplicative articles remained. A full review of these articles eliminated one article not occurring in the United States and five articles presenting adherence or intake values other than food groups dictated by USDA nutrition guides, yielding 31 articles for the final sample. This review included 22 studies that examined adherence to federal dietary guidance (Table 1),[13-34] six that examined knowledge of federal dietary guidance (Table 2),[35-40] and three that examined adherence and knowledge (Table 3).[41-43]

A majority of studies were descriptive, with one experimental study included.[18] Studies in the review involved both children and adults, and five studies targeted a specific population or population characteristics (n=5).[15,27,30,38,42] These targeted populations were NCAA Division I

athletes,[15] Native American Oklahoma women not currently living on a reservation,[27] elderly Kansans participating in a congregate meal program,[30] women with two children or more under the age of 18,[38] and Latinas with or without type 2 diabetes who are neither breastfeeding nor pregnant.[42]

For studies examining adherence to nutrition guides, most used a 24-hour dietary recall (n=8)[13,14,23,26,30,32-34] or validated food frequency questionnaire (FFQ) (n=10).[16-18,24,25,28,29,41-43] All studies examining knowledge (n=9) of nutrition guides used a questionnaire or survey regarding knowledge, behaviors, or attitudes.[35-43] Two studies sampled questions from the NHANES 2005-6 questionnaire,[39,40] and seven studies used unique surveys,[35-41] two of which were tested for validity and reliability.[42,43] Three studies examining knowledge also used a FFQ to test dietary intake.[41-43]

All (n=31) studies reported descriptive statistics, including the mean number of servings of each food group consumed among participants,[13-15,17,19-26,29,33,41,42] percentage of participants meeting minimum food group serving recommendations,[13,16,18,20,23,26-28,30-32] and/or percentage of participants with knowledge of nutrition guides.[35-42] In addition, some studies made comparisons between participant groups based on age,[19] sex,[13,17,19,24,25,26,28,30,34,40,43] and ethnicity/race.[13,14,25,33,39,40,43]

Adherence Studies

Adherence Study Design and Methodology.

Twenty-one adherence studies examined the degree to which participant's dietary intake aligned with recommendations detailed in FGP,[13-27] MyPyramid,[28-30] or a combination of FGP, MyPyramid, DGA 2005, and/or the 5-a-Day program.[31-34] Adherence studies included self-identified longitudinal design,[13,20] cross-sectional design,[14,16,17,34] and all but one[28] were

descriptive. Studies ranged from 28[15] to 215,000[24,25] participants, with many of the larger studies using secondary analysis of national survey data or data from cohort studies.[14,18-21,24,25,31-34] Adults (over the age of 18),[14,15,17,23-27,30-34] children,[13,14,16,19,20,22,28,29,32,33] or both children and adults,[14,32] were identified as participants.

All adherence studies used a dietary recall or FFQ to measure participants' consumption patterns. Eight studies[13,14,23,26,30,32-34] used 24-hour dietary recalls,[44] five studies[3,14,30,32,34] used the Automated Multiple-Pass Method (AMPM) 24-hour dietary recalls,[45] and seven studies[16-18,24,25,28,29] used FFQs.[46,47,48] Two-,[19-22,31] three-,[15,29] and four-day[27] recalls were also used to collect dietary intake.

Adherence Study Results.

Total intake of food groups was reported in two ways: mean intakes of a sample,[13-15,17,19,20,22-26,29,33] or percentage of a sample meeting certain recommendations.[13,16,18,20,23,26-32] Participants across studies tended to consume an inadequate mean amount of fruits.[13-15,17,20,21,29,33] vegetables,[13-15,17,19,20,22,29,33] and dairy,[13,14,20,21,24,25] and exceeded recommendations for proteins.[14,15,21,24,25] Four studies using children as participants found inadequate consumption of grains[22,33] and proteins.[13,20] Two studies, sampling college students,[23,26] found mean intake to meet recommendations for all food groups.

Results reported as percentages described the proportion of a sample meeting a nutrition guide recommendation,[3,16,23,26,30-32] not meeting a recommendation,[18,28] meeting all recommendations,[23,27] and meeting no recommendations.[20,30] The percentage meeting recommendations ranged from 17.7%[30] to 61%[26] for grain, 8.4%[16] to 70%[23] for vegetables, 5%[13] to 62%[26] for fruit, 3.5%[30] to 60%[26] for dairy, and 26%[13] to 54.1%[31] for protein, with children and the elderly at the lower range,[13,16,30] and adults, particularly college students, at the higher

range.[23,26,31] Low adherence to all FGP recommendations was common, with 100% of participants in one study inadequately consuming all food groups,[30] and 0.6%[23] to 6%[27] of participants meeting all recommendations in other studies.

Some studies included comparisons between demographic groups. Eight studies made comparisons between males and females.[13,17,24,[26,28,30,34] Females met FV recommendations servings more frequently than males in several studies,[24,25,30] although one study showed males as more likely to meet vegetable recommendations than females despite no significant difference in mean intake between the sexes.[13] Males consumed more proteins than females,[17,26,28] and were more likely to adhere to protein and grain recommendations.[25]

Four studies compared consumption with ethnicity/race,[13,14,25,33] three of which sampled children.[13,14,33] African-Americans consumed more fruits than whites, and whites consumed more dairy and were more likely to meet dairy recommendations than African-Americans.[13,14] While non-Hispanic blacks scored highest on the FGP Index, a nutrition guide adherence index,[33] the same demographic group was most likely to consume inadequate servings of all food groups.[25]

Ha, Bae, Urrutia-Rojas, and Singh examined the relation between FV consumption and weight status, although no association was found.[16] Those preferring Extraversion, Intuition, and Judgment on the Myerrs Briggs Type Indicator to were more likely to adhere to FGP recommendations.[17] Children receiving WIC foods consumed more FV than those not receiving WIC foods.[22] Lastly, while children from low socioeconomic status (SES) households scored higher on the FGP Index than those from higher SES households,[33] adults at higher income levels were more likely to meet or exceed recommendations than those at lower income levels.[32]

Two studies utilized the Healthy Eating Index-2005 (HEI), to measure nutrition guide

adherence compared to dietary intake reports.[27,34] Both studies featured disadvantaged adult populations from regions of lower SES, and scores for overall adherence ranged from 54.5[27] to 59.3 out of 100.[34] For studies in which component scores of recommendations were given, inadequate consumption of fruits, vegetables, and dairy contributed to low overall adherence score.[34]

Knowledge Studies

Knowledge Study Design and Methodology.

Six studies examined knowledge of FGP,[35,39,40] MyPyramid,[36,37,38] MyPlate,[36-38] 5-a-Day Program,[39,40] DGA 2005,[40] or a combination of the above.[36-40] Adult participants were sampled, with the exception of one study (=17.5).[39] Studies ranged from 51 participants[37] to 5,499 participants,[40] with larger studies using secondary analysis of national health surveys such as the 2005-2006 NHANES.[39,40] Two studies used one-on-one interviews,[35,39] and five studies used surveys.[36-40]

Knowledge Study Results.

All knowledge studies reported results as the percentage of sample with knowledge of the targeted nutrition guides program. Knowledge ranged greatly among and between nutrition guides. Fifteen percent[35] to 92.4%[39] were familiar with FGP. Participants were more knowledgeable of MyPyramid versus MyPlate,[36-38] and participants were more likely to be familiar with MyPlate if they were familiar with MyPyramid.[38]

Some studies compared knowledge between demographic groups or other characteristics. Knowledge of nutrition guides was positively associated with education,[40] income,[40] perception of the guidelines as relevant and easy to use,[38] perception of the guidelines as accurate and helpful,[38] belief that obesity is not a predetermined state,[40] and preference for FV.[38] Whites were

more likely to have heard of DGA 2005 and FGP than African-Americans and non-white Hispanics.[39,40] In one study, women had greater knowledge of nutrition guides than males,[40] and two studies showed knowledge of nutrition guides to decrease with age.[35,40]

Two studies included analysis of participants' acceptance, or belief in effectiveness or accuracy, of nutrition guides.[35,38] Eighty-seven percent of participants trusted FGP to help them achieve a healthy diet,[35] and a significant correlation was found between acceptance of nutrition guides, perception of nutrition guides as relevant and easy to use, and preference for FV.[38]

Adherence and Knowledge Studies

Adherence and Knowledge Study Design and Methodology.

Three studies examined both adherence to and knowledge of FGP.[41-43] Adult participants were used in all studies,[41-43] with children also sampled in one study.[43] Surveys and/or questionnaires and FFQs or food intake records were used in combination in all studies.

Adherence and Knowledge Study Results.

Like in other adherence studies, intake and adherence were reported as percentage of sample meeting, missing, or exceeding FGP recommendations, or mean intake of a food group. Vegetable intake was lower than recommended in two studies,[41,42] although inadequate consumption of grains,[41] proteins,[41] fruits,[43] and dairy[43] was also reported, with 10.3%-16% of participants in one study meeting no FGP serving recommendations.[43]

Knowledge of nutrition guides was measured mostly as percentage aware of FGP or ability to accurately identify recommendations.[41,42] Between 44%[41] and 64.2%[42] had heard of FGP, although 30.6% recalled seeing it before.[41] Grain recommendations were least likely to be accurately identified,[41,42] contrasting the relatively high intake of this food group among participants. One study found a positive correlation between knowledge of FGP, use of food

labels, and consumption of FV.[42]

Comparisons were made between knowledge of nutrition guides, intake, and demographic and behavioral factors. Females in 11th grade were less likely than 11th grade males to consume adequate proteins and dairy, although females had higher nutrition knowledge scores than males.[43] Intake and knowledge also varied by race/ethnicity, with whites more likely than African-Americans to meet recommendations for vegetables, dairy, and protein, and white adolescents more likely than African-American adolescents to meet recommendations for all food groups.[43]

DISCUSSION

This review identified studies to date examining adherence to and knowledge of nutrition guides. The data supported the hypothesis of poor adherence and knowledge across all nutrition guides. The studies in this review also showed evidence of differences in dietary intake between age, sex, and race/ethnicity. From these trends in literature, recommendations can be made to increase knowledge of and adherence to nutrition guides, and to best leverage public health education and federal nutrition programs to close gaps between demographic groups.

Adherence

Studies showed no conclusive evidence that any nutrition guide affected dietary intake more than others, and adherence to nutrition guides was low throughout the studies. Similarly, adherence did not increase over time within a particular nutrition guide. The literature demonstrated trends in consumption of certain food groups.

For studies examining intake in relation to FGP, participants demonstrated low consumption of dairy,[13,14,20-25,27,42] fruits,[13-15,17,20,21,33,42] and vegetables, [13-15,19,20,22,33,41,42] regardless of demographics or aim of study. In three separate studies, less than 50% of

participants met minimum FV recommendations.[16,18,31] While FV intake was often inadequate, protein consumption was often found to exceed FGP recommendations.[14,15,21,24,25] Grains were the food group most likely to be consumed adequately, with low consumption cited in three studies.[22,33,41] Results from a longitudinal study indicated that adherence to the FGP did not change over time.[20]

Participants in studies examining adherence to MyPyramid also demonstrated poor adherence to recommendations. MyPyramid studies were fewer in number than FGP studies, making conclusions more difficult to accurately draw. Participants in these studies consumed inadequate amounts of FV, [29,31] with no participants[28] to 33.6%[30] adhering to all recommendations. No food groups were adhered to by more than 50% of participants, and in one study, no participants met any food group requirements.[30] No studies cited mean inadequate dairy consumption. While no studies were available on adherence to MyPlate recommendations during the data collection period, recent studies show mean intake of fruits, vegetables, and dairy in 2011 to be at 38%, 59%, and 50% of recommendations, respectively.[49] These developments show a continued trend of low adherence to serving recommendations for all nutrition guides,[13-15,17,19-30,33,41,42] and follow-up studies could help identify whether increased emphasis on nutrition education and outreach with MyPlate affects adherence over time.

Studies showed evidence of intake patterns varying between children and adults, with different age groups exhibiting a preference for certain food groups. Children had distinct intake patterns, consuming fewer grains and vegetables than adults.[13,14,19,20,22,23] Notably, several studies showed that children had greater adherence to dairy recommendations than adults,[28,30,32] and federal programs and policies such as the National School Lunch Program and Child and Adult Care Food Program that mandate milk be served during meals could affect dairy consumption

among children.[50-52]

Knowledge

Like the adherence studies, there was no conclusive evidence regarding differences in knowledge of nutrition guides. Both FGP and MyPyramid had high rates of knowledge among participants, with as many as 92.4% aware of the FGP[39] and 92% aware of MyPyramid.[36] Progression of knowledge of nutrition guides was examined in two ways: how age of nutrition guides and how age of participants affects knowledge. Evidence supported increased knowledge of nutrition guides over time, as well as decreasing knowledge of nutrition guides with increasing age.

Participants' knowledge of nutrition guides increased over time, suggesting a need for public health education to be given time to circulate before evaluating outcomes. This trend was supported by studies examining FGP in which knowledge increased over 12 years,[35,39,40-43] even as a new nutrition guide was introduced.[39,40] Knowledge of MyPyramid also increased over time, and 80.4% were aware of MyPyramid in 2010,[37] compared to 92% in 2012.[36] Additionally, multiple studies showed that participants were more aware of MyPyramid, released in 2005, than MyPlate, released in 2010,[36-38] with knowledge of MyPyramid as much as tripling that of MyPlate in one study.[36]

Lastly, studies in this review showed evidence for decreased knowledge of nutrition guides with increasing age of participants, which may be explained in part by the influence of school systems and education in promoting nutrition guides, although other factors have influence adult knowledge of federal nutrition guides.[35,39,40,43]

Association Between Knowledge and Consumption

This review also examined whether knowledge of nutrition guides correlates with

adherence, and no positive relationship between these two variables was found. This confirms health behavior theory stating that knowledge does not equal behavior.[53] Studies that included analysis of both knowledge and adherence demonstrated inverse relationships. In one study, adults had lower nutrition knowledge scores than children, but a larger percentage of children met none of the FGP recommendations,[43] showing evidence of decreasing adherence with increasing knowledge. Similarly, in one study, 66% could identify FGP dairy recommendations, which was one of only two food groups adequately consumed by the group.[41] Comparing knowledge and adherence between studies, no positive relationship emerged. Despite high rates of knowledge of FGP and MyPyramid, especially over time, overall rates of adherence were low, and did not improve over time. In one study, 85% of participants had heard of or seen FGP, and 87% believed in and trusted the nutrition guide for accurate nutrition information, but only 25%, actually used FGP in meal planning.[23] Knowledge of a nutrition guide or nutrition campaign is ineffective if individuals cannot apply the guidelines to their daily lives, making behavioral strategies key in designing effective nutrition guides,[23,54] and knowledge has been shown to be an inconclusive determinant of actual dietary intake or health behavior patterns.[29,31,55-58]

Comparing Demographic Variables

Studies in this review showed strong evidence of differences in consumption[13,17,24-26,30,34] and moderate evidence of differences in knowledge[40,43] between males and females. In general, females consumed more FV,[24,25,40] had higher overall HEI scores[34], and had a greater knowledge of nutrition and nutrition guides than males.[43] Females had low protein consumption, particularly in comparison to males.[17,25,26,28,43] Future dietary guidance should address these disparities in consumption patterns between males and females, potentially caused by sociological factors (e.g., gender norms) that dictate different body ideals and consumption patterns for the sexes

(e.g., promote minimal intake in females).[59-63]

Studies made distinct comparisons between racial/ethnic groups regarding adherence,[14,25,33] and knowledge,[39,40,43] and disparities existed between whites[13,14,43] and African-Americans,[13,14] as well as between different age groups within racial/ethnic groups.[27,28,31] Minorities and those of lower SES are more likely to experience chronic disease,[64] and this disparity, coupled with the observed disparity between knowledge and adherence, suggest a connection between adherence, knowledge, and health outcomes.

Gaps and Limitations

While the studies in this review cover a span of 28 years and three nutrition guides, a plethora of opportunities remain in determining knowledge of and adherence to nutrition guides over time and identifying ways of improving public health programs and the US population's health status.[1-3] The studies in this review failed to examine long-term adherence to nutrition guides, and viewing current dietary intake through the lens of past nutrition guides could offer an interesting perspective on the state of public health outreach in the US. Many studies utilized small sample sizes, which allowed for nuanced examination of specific populations, but limited applicability to the general population. The inclusion of both large, secondary analyses of national data in addition to smaller studies with more specific populations provided a more complete assessment of intake and knowledge, particularly in regards to historically marginalized populations. While thorough in its scope, the breadth of the studies used in this review, covering many nutrition guides, target populations, methods, purposes, and analyses, limited the ability to use one standardized statistic to convey adherence and knowledge of nutrition guides. Future research would benefit from identifying standards for quality and sample size of studies, as well as including adherence evaluation tools such as HEI in the search criteria.

The Healthy Eating Index is used for evaluating population adherence to federal dietary guidance, specifically DGA.[65] This tool provides detailed, valuable insight regarding the population-wide dietary intake, and should not be discounted as an asset in analyzing national intake trends and effect of federal dietary guidance. Healthy Eating Index, however, does not report the absolute number of servings consumed by the sample, calculates overall adherence using factors not shown in nutrition guides such as nutrients (e.g. concrete sodium recommendations) or food group subcategories (e.g., dark leafy greens), and does not examine knowledge of nutrition guides or federal dietary guidance. While not exclusively suited for this review, future studies might incorporate more adherence factors and utilize Healthy Eating Index as a tool in evaluating dietary quality. Additionally, adherence to and knowledge of MyPlate should be assessed as this nutrition guide, now in its relative nascence, continues to be promoted through outreach and education efforts.

Recommendations

Federal agencies, policymakers, and other key stakeholders should establish effective dietary guidance and policy strategies that will maximize knowledge and adherence to nutrition standards. The trends in adherence and knowledge of populations found in this review point to shortcomings in public health education and implementation of otherwise scientifically sound nutrition guidelines. As MyPlate continues to be institutionalized and DGA 2015 begin to be formulated, particular attention should be paid to aligning recommendations with policy. MyPlate recommendations state, for example, that FV constitute half of one's diet, but receive less than 2% of funding from the 2008 Farm Bill. [66]

Additionally, those responsible for marketing and rollout of nutrition guides could strengthen public health initiatives by ensuring a strong aesthetic and visual aspect in their design

of nutrition guides. In one example, two years after its rollout, FGP was familiar in name to 44% of participants, but only 70% of those participants could actually recall seeing it, potentially resulting in inadequate consumption of three of five food groups.[41] Studies examining other nutrition guides found even poorer results.[39,40] Nutrition guides, are highly tested for usability, relevance, and preference through focus groups, interviews, media analysis, and environmental scans.[67,68] MyPlate was designed to meet consumers' expressed needs for a nutrition guide that is simple yet different enough from FGP or MyPyramid to be recognizable as containing new nutrition information.[67] Future studies might examine whether this emphasis on *sustained visibility* affects knowledge of or adherence to nutrition guides.

To achieve desired health outcomes associated with adherence to dietary guidelines, nutrition programs must accommodate population nutrient needs. In this review, for example, dairy consumption was very low among adult populations, particularly among racially and ethnically diverse samples.[14,11,24,25,27,42] Lactose intolerance is most common among African Americans, Hispanic Americans, American Indians, and Asian Americans.[69] DGA 2010 only suggests that lactose intolerant populations eat smaller amounts of dairy products or lactose-free dairy products instead of finding alternatives for dairy products.[67] DGA 2015, as well as other future nutrition guides, should provide accommodating guidance that assists all populations in meeting their nutrient needs

In addition to the mandated DGA and complementary nutrition guides, the US government also develops federal nutrition programs targeting specific foods or food plans for either advancement of public health, such as 5-a-Day[70] or market expansion through efforts such as commodity checkoffs.[71] Tailored development of dietary guidance that is effective in achieving better health outcomes should be a priority for federal agencies and key stakeholders.

Despite its launch in 1991, only 43.5-51.2% of participants could identify the 5-a-Day program in 2005-2006.[27,28] Of the 25 studies examining dietary intake in this review,[13-34] 17 cited mean inadequate intake of FV by participants[14,15,17,19-22,33,41,42] or fewer than 50% of participants meeting recommendations for these food groups.[16,18,30-32] Similarly, the Fluid Milk Promotion Act of 1990 established the National Fluid Milk Processor Promotion Board in 1994 to promote milk consumption and provide funding for education and outreach programs[71], but dairy consumption has been shown to be inadequate among participants in many of the studies included in this review.[13,14,20,21,24,25,27,42] Consumption of fruits, vegetables, and low-fat dairy products have been associated with decreased risk of obesity, and increasing the effectiveness of these programs to improve national dietary intake trends could help in reversing high obesity rates. Obesity rates have fallen for children ages 2-5 participating in federal nutrition programs that mandate availability of fruits, vegetables, and low-fat dairy, suggesting that federal dietary guidance, if properly promoted and followed, can have positive health outcomes.[1,54]

CONCLUSION

Policymakers, practitioners, and researchers should apply these study findings to developing future nutrition guides. Given the lack of evidence that knowledge leads to behavior, future nutrition programs and policies should emphasize alternative motivating variables in promoting adherence to nutrition guides. It is in the best interest of federal agencies to develop nutrition guides that clearly expresses nutrition standards and principles for a public with a wide range of skills and attitudes about nutrition. MyPlate embodies this strategy well, presenting servings as straightforward proportions in the most applicable of settings – a plate. Future research, development, and implementation of nutrition guides should focus on public messaging that resonates with a diversity of demographics and is utilized in a number of settings (e.g.,

schools, computers, supplemental food programs). In addition, policymakers should focus on passing policies that promote behavioral and environmental strategies that align with DGA. Creating nutrition guides that makes an impact on the dietary intake of the American population will assist nutrition educators, researchers, and policymakers in the development of evidence-based strategies that promote future population health. As shown by the latest decline in early childhood obesity, federal nutrition policies and programs can play a large role in affecting health status and health outcomes, and much is at stake in ensuring federal dietary guidance and nutrition guides are properly developed, marketed, and utilized.

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645 **TABLES**

Table 1. Overview of United States federal dietary guidance adherence studies 1992-2013 (n=22)

First author (year)	Food guide	Purpose	Data collection methods	Sample size, demographics	Results[a]
FGP[b] (n=15)					
Brady et al. (2000)[13]	FGP	Compare children's dietary intake with FGP; determine whether sex or ethnic differences were evident	AMPM[b] 24-hour dietary recall	n=110, ages 7-14 (self-reported)	Average daily intake below minimum servings for all food groups except grain; 5% met fruit servings, 9% met dairy servings, 20% met vegetable servings, 26% met proteins servings, and 46% met grain servings; more males (30%) met vegetable servings than females (13%); African-American children consumed significantly higher mean servings of fruit than whites (P<0.001); white children more likely to meet dairy requirements than African-Americans (P<0.001); African-American children more likely to meet proteins requirements (P<0.01)
Champagne et al. (2004)[14]	FGP	Evaluate food intake data from a culturally diverse population	AMPM 24-hour dietary recall	n=1,727, ages 3 and older (assisted interview)	Servings of fruits (1.0, 1.3) and dairy (1.3, 0.8) lower than recommended for both white and African-American

					groups; servings of proteins (5.8) higher than recommended for both groups (adults); significantly higher consumption of fruits by African-Americans than whites (P=0.0005); significantly higher consumption of vegetables and dairy by whites than African-Americans (P=<0.0001) (adults); servings of fruit (1.1, 1.6), vegetables (2.2, 2.7), and dairy (2.0, 1.6) lower than recommended for both African-Americans and whites; servings of proteins (4.1) higher than recommended for both groups (children); significantly higher consumption of fruit by African-Americans than whites (P=0.004); significantly higher consumption of dairy by whites than African-Americans (P=0.0077) (children)
Cole et al. (2005)[15]	FGP	Evaluate the diet of NCAA Division I athletes	Two sets of 3-day dietary recalls	n=28, student athletes ages 19-23	Diets lacking in fruits and vegetable servings (1.6 and 1.3, respectively); participants consumed more

					protein than recommended by FGP (4.2)
Ha et al. (2005)[16]	FGP	Identify eating patterns among overweight children compared to FGP	Self-reported FFQ[b]	n=1076, demographically representative 5th graders in Forth Worth, Texas (self-reported)	25% met FGP recommendations for fruit; 8.7% met serving recommendations for vegetables; no association between fruit/vegetable consumption and being overweight/at risk of overweight
Horacek et al. (1998)[17]	FGP	Evaluate differences in college students' dietary intake in relation to their Myers Briggs personality type	Adapted version of NCI[b] Health Habits and History Questionnaire; Myerrs Briggs Type Indicator Test	n=302, 67% female, 33% male	Low vegetable consumption among all personality types (1.68-1.93); low fruit consumption among groups (.95-1.28); low proteins consumption among all women (1.71-1.84)
Kant et al. (1997)[18]	FGP	Construct dietary variety measurements using FFQ	FFQ	n=10,799, ages 18 or older	Over 70% reported consuming fewer than two servings of fruits a day; over 80% reported consuming fewer than two servings of vegetables a day
Knol et al. (2006)[19]	FGP	Assess the diet of children in relation to FGP	Two 24-hour dietary recalls	n=2,8152, ages 3-8; n=3,789, ages 4-8 (proxy interview ages 3-6, assisted interview ages 6-8)	Fruit servings and food group adherence scores ($P<0.01$) decreased by age; all age groups and genders consumed fewer servings than

					recommended for total vegetables
Lee SK et al. (2007)[20]	FGP	Describe changes in dietary patterns of adolescent girls in Hawaii from 2001 to 2003	Three-day dietary recalls	n=151, ages 9-14 at onset (self-reported)	Participants consumed fewer servings than recommended for dairy (1.5), fruit (1.3), vegetable (2.1, 2.0), and proteins (3.6, 3.5) groups at both exams; more than half of participants did not meet any FGP recommendations for any food group at either exam; no significant difference in adherence to food groups between exams
McNamara PE et al. (1999)[21]	FGP	Measure gap between dietary guidelines and estimated food intakes	Two-day average dietary recall	n= 4,953, demographically diverse sample	For all age groups, genders, and ethnicities, lower than recommended consumption of fruits (1.5), dairy (1.5); higher than recommended consumption of proteins (4.8)
Partington et al. (2000)[22]	FGP	Determine if diet quality of WIC[b] participants is affected by foods provided by WIC	24-hour dietary recall	n=179, ages 2 and older, Wisconsin residents, children of WIC recipients (proxy interviews)	Children receiving WIC foods consumed more fruits and vegetables than those not receiving WIC benefits ($P<0.05$); inadequate vegetable (1.51-2.14) and grain (4.15-5.35) consumption for WIC and non-WIC recipients

Schuette et al. (1996)[23]	FGP	Evaluate usefulness of FGP as a quantitative tool for assessing nutritional adequacy and quality	24-hour dietary recall	n=2,489, college students	Daily mean intakes for all food groups were at or above minimum serving recommendations; percentage of students meeting minimum recommended number of servings ranged from 45% for proteins to 70% for vegetables; 33% consumed no fruit; only 0.6 % met all minimum food group requirements
Sharma et al. (2003)[24]	FGP	Examine food group intake of Japanese Americans, Native Hawaiians, and whites	FFQ	n=215,000, ages 45-75	Inadequate consumption of dairy (0.8-1.6) and excessive consumption of proteins (4.0-7.3) across all ethnicities and genders; greater adherence by women to fruit and vegetable servings
Sharma et al. (2004)[25]	FGP	Determine degree of adherence to FGP for African Americans, Latinos born in US, and Latinos born in Mexico	FFQ	n=215,000, ages 45-75	Inadequate consumption of dairy (1.1-1.9) and excessive consumption of proteins (5.5-8.8) across all ethnicities and genders; women adhered more to fruit and vegetable groups; men adhered more to proteins and grain groups; African-Americans had greater percentage of people not adhering to recommendations

					for all food group
Song et al. (1996)[26]	FGP	Determine food group intake in relation to FGP	24-hour dietary recall	n=2,489, college students	Adequate consumption of all food groups by both men and women except proteins consumption by women; participants consuming at least the minimum servings grain, vegetable, fruit, dairy, and proteins: 61%, 69%, 62%, 60%, and 45%, respectively; participants consuming no servings of grain, vegetable, fruit, dairy, and proteins: 1%, 8%, 33%, 10%, and 9%, respectively
Taylor et al. (2003)[27]	FGP	Assess dietary intake of Native American women who do not reside in reservation settings in relation to FGP	Four-day weighted food record	n=71, Native Americans female participants ages 18-65, residents of Oklahoma	Overall HEI[b] score of 59.3, signifying low nutritional intake; very low consumption of fruit and dairy (2.7 and 3.0); four of 71 participants (6%) met minimum FGP requirements
MyPyramid (n=3)					
Hovland et al. (2010)[28]	MyPyramid	Determine whether Food, Math, and Science Teaching Enhancement Resource Initiative (FoodMASTER) curriculum in rural Ohio	Block Kids FFQ 2004	n=138, 3rd grade students living in Ohio (self-reported)	High rates of noncompliance of food guide recommendations of food group serving ranging from 100% noncompliance (grain consumption among males) to 71.1% (dairy consumption among

		elementary schools improved dietary intake			females); male children had higher intake of proteins group than females (P<0.05)
Vadivelo o et al (2009)[29]	MyPyra mid	Describe eating patterns and physical activity habits of elementary school children	152-item FFQ; three-day food record	n=35, ages 8-10 (assisted interview)	Fruit (0.83, 1.01) and vegetable (1.3, 0.98) consumption very low among both males and females; overall adequate dairy consumption (2.42)
Weeden et al (2010)[30]	MyPyra mid	Describe and predict food group intake of elderly Kansans (80+ years old) participating in congregate meal program	AMPM 24-hour dietary recall	n=113, ages 80 or older, attending senior centers in rural Kansas	No participant met recommendations for all food groups; females more likely to meet fruit recommendation than males (P=0.039); participants consuming adequate servings of grain, vegetables, fruits, dairy, and proteins: 17.7%, 20.4%, 33.6%, 3.5%, and 29.2%, respectively
Multiple (FGP, MyPyramid, MyPlate, 5-a-Day, and/or DGA[a]) (n=4)					
Guenther et al. (2006)[31]	FGP; MyPyra mid	Estimate proportion of population eating recommended servings of fruits and vegetables	One- or two-day 24-hour dietary recalls	n=23,033, demographically diverse sample	Only 40% of people met FGP recommendations for fruit and vegetable servings; less than 11% adhered to fruit and vegetable serving recommendations among those 18 years or older
Kirkpatrick et al. (2012)[32]	MyPyra mid; DGA	Align food group and nutrient intake by family	AMPM 24-hour dietary recall	n=16,338, demographically diverse sample	Adults with higher incomes more likely to meet or exceed food group

		income and race/ethnicity			recommendations (P<0.05); participants meeting or exceeding food group recommendations for fruits, vegetables, grains, proteins, and dairy: 17.5%, 12.9%, 58.9%, 54.1%, and 7.7%, respectively (adults); participants meeting or exceeding food group recommendations for fruits, vegetables, grains, proteins, and dairy: 28.7%, 6.6%, 80.7%, 43.8%, and 37.1%, respectively (children)
Melnik et al. (1998)[33]	FGP; 5-a-Day	Examine food consumption patterns of children	Household questionnaire and non-quantitative 24-hour dietary recall	n=693, 2nd grade students; n=704, 5th grade students (self-reported)	Participants only met recommendations for dairy (2.5) and (2.2) proteins and consumed fewer servings than recommended of grains (3.1), vegetables (1.3, and fruit (1.9); mean FGP Index score of 29.2 for 2nd graders and 30.4 for 5th graders; 5th graders from low SES[b] households scored higher on FGP index (P<0.02); black non-Hispanic 5th graders scored higher on FGP index (P<0.02)

Thomson JL, (2011)[34]	MyPyramid; DGA	Evaluate diet of Lower Mississippi Delta residents	AMPM 24-hour dietary recall	n=1,689, demographically representative	Mean HEI scores higher for women than men; average HEI score of 54.5 pointing to lack of nutrients

[a]Values denote servings unless otherwise specified
[b]Abbreviations: FGP, Food Guide Pyramid; AMPM, Automated Multiple Pass Method; FFQ, Food Frequency Questionnaire; NCI, National Cancer Institute; CSFII, Continuing Survey of Food Intakes by Individuals; WIC, Women, Infants, and Children; HEI, Health Eating Index; DGA, Dietary Guidelines for Americans; NHANES, National Health and Nutrition Examination Survey

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Table 2. Overview of United States federal dietary knowledge studies 1992-2013 (n=6)

First author (year)	Food guide	Purpose	Data collection methods	Sample size, demographics	Results
Gillham et al. (1999)[35]	FGP[a]	Examine cultural variations in use, knowledge, and adherence to FGP	Guided interview featuring questions regarding "socioeconomic and cultural variations in knowledge, use and attitudes about the pyramid."	n=115, primary purchasers for household	85% had heard of or seen FGP; 87% believed and trusted FGP; 75% did not use FGP in meal planning; participants over 50 less likely to be familiar with FGP than those under 50
McKinley et al. (2012)[36]	MyPyramid; MyPlate	Assess college students' familiarity with MyPlate, MyPyramid icons, and serving recommendations	Survey administered featuring both food guides and questions as to their constituent food groups and serving recommendations	n=61, ages 18-23 and enrolled at a university	Eleven of 61 participants (18%) familiar with MyPlate and MyPyramid, but 56 of 61 (92%) familiar with MyPyramid; participants significantly more likely to accurately predict food group servings from looking at MyPlate

					than at MyPyramid
Uruakpa et al. (2013)[37]	MyPyramid; MyPlate	Assess consumer awareness of MyPlate's replacement of MyPyramid; determine MyPlate's influence on population's diet four months after MyPlate's release	11-question survey examining participants' demographic background, familiarity with MyPyramid and MyPlate, likelihood of use of nutrition guides, and influence of nutrition guides on food choices	n=51, ages 18-34	Forty-one of 51 participants were (80.4%) familiar with MyPyramid; 23 of 51 (45.1%) were familiar with MyPlate; 22 of 51 (43.1%) knew that MyPlate had replaced MyPyramid; 35 of 51 (68.6%) had noticed replacement of "protein" to "proteins and beans;" twenty-two of 51 (43.1%) indicated MyPlate might influence their diet, 22 of 51 (43.%) indicated they were unsure of how MyPlate would influence their diet
Wansink et al. (2013)[38]	MyPyramid; MyPlate	Understand characteristics of mothers who were early adopters of MyPlate	Survey including demographic and behavioral questions regarding use of MyPlate and attitudes towards MyPlate	n=497, women ages 18-65 with at least two children ages 18 or younger	30% familiar or somewhat familiar with MyPlate; 62% familiar or somewhat familiar with MyPyramid; significant correlation between familiarity with MyPlate and belief MyPlate would help them (P=0.002) and their children (P=0.009) eat better, finding MyPlate

					easy to understand (P=0.001), preference for fruits and vegetables, and familiarity with MyPyramid (P<0.01); significant correlation between belief MyPlate would help them eat better and finding MyPlate relevant and easy to understand (P<0.01) and preference for vegetables (P<0.01)
Wojcicki et al. (2012)[39]	FGP; 5-a-Day; DGA[a]	Assess awareness of federal nutrition programs and relation between nutrition programs, food label use, and obesity	Home interviews examining nutrition awareness and use of nutrition labels in making food choices	n=1160, mean age 17.5 +/- 1.1 years	92.4% aware of FGP, 29.3% aware of DGA, and 43.5% aware of 5-a-Day Program; whites were more significantly more likely to have heard of DGA and FGP than African-Americans, other Hispanics, and Mexican-Americans (P<0.05); no significant correlation between being overweight/obese and awareness of nutritional programs or use of food labels
Wright et al. (2011)[40]	FGP; 5-a-Day; DGA	Relate awareness of federal dietary guidelines with diet-related behaviors and attitudes	Survey featuring questions on awareness of federal dietary guidance, demographic characteristic	n=5,499, ages 16 and older	83.8% had heard of at least one set federal nutrition program; 49.2% had heard of DGA, 80.6% had heard of FGP; 51.2% had heard of 5-A-Day program;

		s, and diet-related behaviors and attitudes	significantly significant (P<0.01) linear trend of increasing awareness of nutrition programs with decreasing age, increasing education and increasing awareness with increasing income levels; women had significantly (P<0.01) greater chance of having heard of at least one program; whites significantly more likely to have heard of at least one program than non-Hispanic blacks or Mexican-Americans (P<0.01); non-Hispanic blacks significantly more likely to have heard of at least one program than Mexican-Americans (P<0.01); no significant correlation between awareness of any federal dietary guidance and diet-related behaviors; significant (P<0.01) linear trend of decreasing awareness of federal dietary guidance with increasing agreement that people are born to be fat or thin

[a]Abbreviations: FGP, Food Guide Pyramid; DGA, Dietary Guidelines for Americans; NHANES, National Health and Nutrition Examination Survey

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Table 3. Overview of food guide adherence and knowledge/awareness studies (n=3)

First author (year)	Food guide	Purpose	Data collection methods	Sample size, demographics	Results
Cotugna et al. (1994)[41]	FGP[a]	Determine awareness of FGP, food group servings, and how intake compares to FGP	Questionnaire regarding awareness of FGP and knowledge of food group servings; FFQ[a]	n= 85, ages 17 to 44	Thirty-seven of 85 participants (44%) had heard of FGP, 26 of whom (70%) had actually seen it; four of 85 (5%) could correctly identify grain group servings and 56 of 85 (66%) could identify fruit; average consumption met minimum serving requirements for only dairy and fruit group
Fitzgerald et al. (2008)[42]	FGP	Examine food knowledge and intake patterns among Latinas with and without diagnosed type 2 diabetes	25-item nutrition knowledge questionnaire; 18-item FFQ; food labeling use questionnaire; Transtheoretical Model and Social Cognitive Theory questionnaire	n=201, Latinas with or without type 2 diabetes ages 35-60 living in Hartford, Connecticut who are neither pregnant nor breastfeeding	Participants consumed inadequate dairy (1.84) and fruit and vegetable (3.60) servings; 35.8% had not heard of FGP; most could not identify FGP serving recommendations (from 44.2% for dairy to 93.8% for grains);

					participants with greater nutrition knowledge more likely to use food labels to select more healthful foods (P=0.007) after controlling for variables; women with more nutrition knowledge more likely to consume more fruits and vegetables (P<0.05); no significant difference in nutrition knowledge between those with and without diabetes
Rafiroiu et al. (2002)[43]	FGP	Assess and identify correlates of adolescents' and parents' compliance with FGP	Survey of demographic, nutrition behaviors and attitudes, and food intake questions	n=2,021, 1,261 8th graders and 760 11th graders; n=1,231, parents of participants (self-reported)	Mean nutrition knowledge score[b] of 8.4 for 8th graders and 8.6 for 11th graders, 5.9 for parents; significantly higher knowledge scores among white 8th graders than African-American 8th graders (P<0.01) and females in 11th grade than males in 11th

				grade (P<0.01); 15% of 8th graders and 16% of 11th graders met none of the FGP recommendation; 10.3% of parents did not meet any recommendations; females in 11th grade less likely than males in 11th grade to meet recommendations for dairy and meat (p<0.05); white adolescents more likely than African-American adolescents to meet recommendations for all food groups (P<0.05); white parents more likely than African-American parents to meet recommendations for vegetables, dairy, and meat (P<0.01)
[a]Abbreviations: FGP, Food Guide Pyramid; FFQ, Food Frequency Questionnaire [b]Number of correct responses to 16 general nutrition knowledge questions, max values=16				

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