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RESEARCH ARTICLE

Dietary Guidance and New School Meal Standards: Schoolchildren's Whole Grain Consumption Over 1994–2014

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Introduction: Since 2005, the federal government's Dietary Guidelines for Americans have recommended at least half of total grain intake be whole grains. Beginning with the 2012–2013 school year, the U.S. Department of Agriculture updated school meal regulations to align with this recommendation.

Methods: Nationally representative food consumption survey data spanning 1994–2014 were analyzed in 2018 to construct a sample of 17,016 schoolchildren aged 5–19 years. Regression models were used to examine changes in whole grain/total grain intake by food source. For school-obtained foods, changes in whole grain intake are decomposed into changes in propensity (proportion of students consuming whole grains) and intensity (amount consumed by whole grain consumers).

Results: The whole grain/total grain ratio from all sources fell from 9.67% (1994–1998) to 7.6% (2005–2006) before climbing to 13.48% (2013–2014). Home-prepared foods topped the whole grain/total grain ratio among all sources until surpassed by school foods in 2013–2014 (17.16% vs 21.48%). The whole grain/total grain ratio from school rose from 4.02% to 21.48% during 1994–2014. Among those consuming school foods, increased intensity contributed more than propensity to increases in whole grain intake from school between 2005–2010 and 2011–2012; the opposite occurred between 2011–2012 and 2013–2014 because of increasing propensity, from one in four to one in two students consuming whole grains.

Conclusions: During 1994–2006, the whole grain/total grain ratio of schoolchildren's diets declined, contrary to expert advice. Following the 2012 U.S. Department of Agriculture school meal regulations, both the propensity and the intensity of whole grain consumption from school rose considerably, demonstrating the important role school meals may play in improving children's diets.

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INTRODUCTION

The Dietary Guidelines for Americans (DGAs) provide advice to Americans on what to eat for a healthy diet and are a central source of guidance for federal nutrition policies including dietary standards for federal food assistance programs, public nutrition information campaigns, and nutrition labeling of foods.[1–3] First issued in 1980, the DGAs are updated every 5 years to ensure consistency with up-to-date scientific knowledge. Although previous editions of the DGAs encouraged whole grain consumption, the 2005 and subsequent editions have given more emphasis and specificity by recommending at least half of total grain intake be whole grains.[1–3] This recommendation is based on consistent

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evidence that, in addition to being a good source of dietary fiber and several micronutrients, whole grain consumption is associated with reduced risk of obesity, type 2 diabetes, cardiovascular diseases, and certain cancers.[4–7]

The DGAs could affect whole grain consumption by influencing consumer behavior in favor of whole grains by spurring a supply response with new and reformulated whole grain products and by prompting more restaurants to offer whole grain options.[8–10] Likewise, the DGAs could affect consumption via federal food program regulations. In 2010, Congress mandated that the U.S. Department of Agriculture (USDA) update school meal regulations to conform to the 2005 DGAs.[11] Implementation of the updated regulations began in the 2012–2013 school year, requiring that at least one half of all grain offerings in school lunches be whole grain–rich (i.e., at least 50% whole grains). Breakfasts were required to meet this standard in 2013–2014, and beginning 2014–2015, both meals were expected to serve only whole grain–rich grains. School foods are a leading source of calories for schoolchildren, averaging 26% of calories on a given school day,[12] and they improve the quality of students' diets, especially among the most disadvantaged.[13]

Given that on a typical school day approximately 30 million and 14 million children consume USDA school lunches and breakfasts, respectively,[14] the new school meal standards could have widespread impacts on children's diets. Several local-level studies have found the new school meal regulations have positive impacts on diet quality.[15–20] Cullen et al.[21] found that after implementation of the new standards, the percentage of school-lunch consuming students eating whole grains from school increased from 5% to 72%, while the mean amount of whole grains consumed from school did not increase. Although these results are encouraging, they are small, local studies, and were conducted over a limited time span.

This study examines whole grain consumption trends among schoolchildren between 1994 and 2014 and how those trends differ by source obtained—home-prepared, school, restaurant, and other food away from home (FAFH). It examines two contributors to changes in whole grain consumption from school: the consumption propensity (the percentage of children eating whole grains on a given day) and the consumption intensity (amounts consumed by those who eat whole grains). Although these analyses cannot establish a causal effect of the DGAs or school meal standards, they provide information on changes in whole grain consumption since publication of the 2005 DGAs and the 2012 school meal standards.

METHODS

Study Population

The sample is drawn from seven nationally representative food intake surveys spanning 1994–2014: the USDA's 1994–1996 and 1998 Continuing Survey of Food Intakes by Individuals (1994–1998) and the continuous waves of What We Eat in America (WWEIA)/National Health and Nutrition Examination Survey (NHANES) conducted by USDA and HHS over 2003–2014.[22,23] The study sample consisted of children aged 5 to 19 years who reported attending school at the time when they participated in the survey. Sample sizes and descriptive statistics for each survey wave are provided in Table 1. Analyses were conducted in 2018.

Measures

All surveys collected 2 days of dietary intake data by employing a multi-pass method found to yield valid intake data.[24–26] The first day was collected using in-person dietary recalls; the second day was a telephone interview. Respondents described foods and amounts consumed, where each food was obtained, and whether it was eaten at home. USDA's food group equivalent databases[27,28] were used to calculate ounces of total grains and whole grains in each food. As documented by USDA, these databases use recipes found in USDA's Food and Nutrient Database for Dietary Studies and assign each ingredient to an appropriate food pattern component (e.g., whole grains).[29]

There are two main categories of food sources: food at home (FAH) and food away from home (FAFH), with the latter separated into three subcategories: school, full-service/fast-service restaurant, and other FAFH (Appendix Table 1). These groupings were chosen to allow exploration of how federal dietary guidelines and federally mandated changes in school offerings correlate with changes in whole grain consumption. Foods obtained at school are primarily those served through the USDA school lunch and breakfast programs but may also include foods sold outside of the USDA programs. Full-service and fast-food establishments, also important food sources for schoolchildren,[30] are combined into a single group "restaurant" due to sample size limitations. Other FAFH sources are diverse (Appendix Table 1).

Statistical Analysis

Descriptive and regression analyses were conducted using the Surveymeans and Surveyreg procedures in SAS, version 9.4 to incorporate complex survey design and sample weights.[31] Descriptive analyses provide trends in average intakes of total grains and whole grains by food source. The first regression analysis examined changes in the whole grain/total grain ratio over time by food source among all schoolchildren while controlling for demographic characteristics.

Changes in average consumption could come from changes in consumption propensity (the decision to eat whole grains at all), from changes in consumption intensity (amounts consumed by those who consume), and their interaction effect (Appendix Text). To decompose changes in whole grain consumption from school, two separate regressions were required. Among those who ate school foods, propensity was estimated by a logistic regression, and intensity was estimated by a regression conditional on positive whole grain consumption (ounces/day). The relative impact

Table 1. Descriptive Statistics of the Sample and Grain Consumption Among U.S. Schoolchildren: 1994–2014

Demographics and grain consumption	Survey years						
	1994–1998	2003–2004	2005–2006	2007–2008	2009–2010	2011–2012	2013–2014
Sample size	3,617	2,540	2,641	2,016	2,118	2,035	2,049
Demographics							
Male, %	51.71 (49.72, 53.71)	52.39 (49.38, 55.39)	52.15 (48.00, 56.29)	49.11 (45.03, 53.19)	49.20 (45.75, 52.66)	49.40 (45.33, 53.46)	52.52 (48.84, 56.19)
Age, years, %							
5–10	45.37 (43.28, 47.46)	44.39 (39.12, 49.65)	43.80 (39.89, 47.70)	41.44 (36.83, 46.05)	43.36 (40.93, 45.79)	44.62 (41.60, 47.63)	42.85 (38.90, 46.81)
11–14	32.20 (29.88, 34.52)	30.76 (28.28, 33.23)	29.85 (27.46, 32.25)	31.24 (27.24, 35.23)	29.67 (27.06, 32.28)	29.92 (25.62, 34.22)	29.01 (26.04, 31.97)
15–19	22.43 (20.56, 24.29)	24.86 (20.02, 29.70)	26.35 (22.83, 29.87)	27.32 (24.05, 30.60)	26.97 (24.14, 29.80)	25.46 (21.51, 29.41)	28.14 (24.21, 32.07)
Race and ethnicity, %							
Non-Hispanic white	66.16 (61.37, 70.95)	62.37 (53.26, 71.48)	61.73 (52.73, 70.72)	59.72 (51.94, 67.51)	57.67 (48.81, 66.54)	55.59 (44.31, 66.86)	53.10 (41.09, 65.10)
Non-Hispanic black	15.67 (12.87, 18.48)	15.37 (10.13, 20.60)	14.54 (8.52, 20.55)	15.22 (10.08, 20.36)	14.20 (11.56, 16.83)	13.63 (7.24, 20.02)	14.40 (9.14, 19.66)
Hispanic	13.56 (9.32, 17.80)	15.82 (9.15, 22.49)	16.08 (12.52, 19.63)	19.94 (13.11, 26.76)	21.54 (13.03, 30.04)	22.65 (15.46, 29.85)	23.14 (14.64, 31.64)
Other race/ethnicity	4.60 (3.42, 5.78)	6.44 (3.58, 9.30)	7.66 (4.27, 11.05)	5.12 (2.98, 7.26)	6.59 (4.47, 8.72)	8.13 (5.30, 10.96)	9.37 (6.73, 12.00)
Household income, % federal poverty guideline							
<185%	38.50 (35.10, 41.91)	41.03 (35.44, 46.63)	36.15 (29.88, 42.42)	43.26 (36.48, 50.04)	45.70 (39.97, 51.43)	49.17 (39.85, 58.50)	45.78 (36.30, 55.26)
185%–300%	21.11 (18.51, 23.71)	20.76 (16.60, 24.92)	21.17 (17.13, 25.21)	17.27 (13.12, 21.42)	15.86 (12.86, 18.85)	18.27 (13.17, 23.38)	16.81 (12.89, 20.72)
>300%	40.39 (36.81, 43.96)	38.20 (31.65, 44.75)	42.68 (34.75, 50.61)	39.47 (32.00, 46.94)	38.45 (32.71, 44.18)	32.56 (26.31, 38.80)	37.41 (26.96, 47.87)
Weekend, %	28.66 (25.76, 31.56)	28.91 (24.41, 33.42)	29.08 (25.71, 32.45)	30.01 (25.92, 34.19)	30.25 (25.31, 35.18)	30.53 (27.90, 33.15)	29.77 (26.65, 32.88)
Household head education, %							
Less than high school	10.44 (8.14, 12.75)	15.45 (11.49, 19.41)	15.10 (11.44, 18.76)	14.90 (11.96, 17.84)	16.19 (11.95, 20.43)	19.54 (16.07, 23.01)	14.26 (10.73, 17.80)
High school	29.54 (26.91, 32.17)	22.29 (18.74, 25.85)	19.05 (15.36, 22.74)	20.46 (16.73, 24.20)	20.44 (15.78, 25.10)	16.82 (12.43, 21.21)	18.52 (13.84, 23.19)
Some college	25.84 (22.60, 29.07)	37.16 (32.46, 41.87)	32.62 (26.77, 38.47)	32.56 (27.33, 37.79)	28.82 (25.49, 32.15)	30.08 (24.84, 35.32)	29.83 (25.61, 34.06)

(*continued on next page*)

Table 1. Descriptive Statistics of the Sample and Grain Consumption Among U.S. Schoolchildren: 1994–2014 (*continued*)

Demographics and grain consumption	Survey years						
	1994–1998	2003–2004	2005–2006	2007–2008	2009–2010	2011–2012	2013–2014
College	34.18 (29.71, 38.64)	25.09 (19.77, 30.41)	33.23 (25.28, 41.18)	32.08 (24.87, 39.29)	34.56 (28.27, 40.85)	33.56 (26.11, 41.01)	37.39 (28.78, 46.01)
Daily intake of total grains by source (oz/day)							
All sources	7.09 (6.90, 7.29)	**7.45**[a,b] **(7.16, 7.75)**	7.25 (6.93, 7.56)	**6.67**[a] **(6.36, 6.98)**	7.01 (6.64, 7.38)	7.07 (6.75, 7.39)	6.98 (6.70, 7.26)
FAH	**4.82**[b] **(4.60, 5.04)**	4.64 (4.28, 5.01)	4.60 (4.22, 4.97)	**4.33**[a] **(4.02, 4.64)**	4.71 (4.42, 5.00)	**4.26**[a] **(4.08, 4.45)**	**4.36**[a] **(4.10, 4.63)**
FAFH	**2.28**[b] **(2.15, 2.40)**	**2.81**[a] **(2.57, 3.06)**	**2.65**[a] **(2.39, 2.91)**	**2.34**[b] **(2.20, 2.48)**	2.30 (2.01, 2.60)	**2.81**[a] **(2.55, 3.07)**	**2.62**[a] **(2.40, 2.84)**
Restaurant/Fast food	**1.14**[b] **(1.05, 1.24)**	**1.92**[a,b] **(1.71, 2.12)**	**1.69**[a,b] **(1.44, 1.94)**	**1.35**[a] **(1.23, 1.46)**	1.29 (1.10, 1.49)	**1.58**[a] **(1.41, 1.75)**	**1.41**[a] **(1.23, 1.58)**
School	0.63 (0.57, 0.69)	0.62 (0.46, 0.78)	**0.50**[a,b] **(0.39, 0.60)**	0.61 (0.45, 0.76)	0.65 (0.47, 0.83)	0.71 (0.57, 0.86)	0.80 (0.63, 0.97)
Daily intake of whole grains by source (oz/day)							
All sources	**0.66**[b] **(0.59, 0.73)**	**0.49**[a,b] **(0.43, 0.56)**	**0.51**[a,b] **(0.41, 0.60)**	**0.52**[a,b] **(0.44, 0.59)**	**0.59**[b] **(0.55, 0.63)**	**0.74**[b] **(0.68, 0.80)**	**0.86**[a] **(0.76, 0.96)**
FAH	0.58 (0.52, 0.65)	**0.42**[a,b] **(0.35, 0.49)**	**0.44**[a,b] **(0.35, 0.53)**	**0.46**[a,b] **(0.38, 0.53)**	0.53 (0.48, 0.57)	0.62 (0.56, 0.67)	0.61 (0.50, 0.72)
FAFH	**0.08**[b] **(0.06, 0.09)**	**0.07**[b] **(0.05, 0.10)**	**0.07**[b] **(0.05, 0.09)**	**0.06**[b] **(0.05, 0.07)**	**0.06**[b] **(0.04, 0.08)**	**0.13**[a,b] **(0.09, 0.16)**	**0.25**[a] **(0.21, 0.30)**
Restaurant/Fast food	**0.02**[b] **(0.01, 0.02)**	0.03 (0.01, 0.06)	**0.02**[b] **(0.02, 0.03)**	**0.02**[b] **(0.01, 0.03)**	**0.02**[b] **(0.01, 0.03)**	**0.03**[b] **(0.01, 0.04)**	**0.06**[a] **(0.03, 0.08)**
School	**0.02**[b] **(0.02, 0.03)**	**0.02**[b] **(0.01, 0.03)**	**0.02**[b] **(0.01, 0.03)**	**0.02**[b] **(0.01, 0.04)**	**0.03**[b] **(0.02, 0.05)**	**0.06**[a,b] **(0.04, 0.08)**	**0.18**[a] **(0.13, 0.22)**
Whole grain share of total grain, %							
All sources	**9.67**[b] **(8.81, 10.52)**	**7.45**[a,b] **(6.65, 8.24)**	**7.60**[a,b] **(6.15, 9.05)**	**8.67**[b] **(7.07, 10.27)**	**9.34**[b] **(8.73, 9.95)**	**11.43**[a] **(10.10, 12.77)**	**13.48**[a] **(11.69, 15.27)**
FAH	**3.08**[b] **(1.84, 14.32)**	**11.38**[b] **(9.62, 13.13)**	**11.61**[b] **(9.41, 13.80)**	**12.29**[b] **(10.08, 14.50)**	**13.69**[b] **(12.34, 15.04)**	**16.72**[a] **(14.29, 19.14)**	**17.16**[a] **(14.14, 20.17)**
FAFH	**4.01**[b] **(3.25, 4.76)**	**3.88**[b] **(2.44, 5.32)**	**3.57**[b] **(2.50, 4.63)**	**3.66**[b] **(2.93, 4.38)**	**3.56**[b] **(2.87, 4.25)**	**5.75**[a,b] **(4.33, 7.17)**	**10.72**[a] **(8.55, 12.90)**
Restaurant/Fast food	**1.59**[b] **(1.02, 2.17)**	**2.43**[b] **(0.48, 4.37)**	**2.41**[b] **(1.30, 3.52)**	**2.55**[b] **(1.34, 3.77)**	**3.01**[b] **(1.27, 4.74)**	**2.95**[b] **(1.43, 4.47)**	**5.17**[a] **(3.83, 6.50)**
School	**4.02**[b] **(2.84, 5.20)**	**4.35**[b] **(1.35, 7.35)**	**4.51**[b] **(2.11, 6.91)**	**4.82**[b] **(3.69, 5.95)**	**5.65**[b] **(3.61, 7.69)**	**8.63**[a,b] **(6.43, 10.84)**	**21.48**[a] **(18.51, 24.45)**

Note: Data are shown as mean (95% CI). Differences in grain consumption and shares were tested by using both variance and covariance. Boldface indicates statistical significance at $p<0.05$. This study tested only the differences between the 1994–1998 data and the 2013–2014 data, the beginning and ending surveys covered in the study. "Weekend" indicates intake occurred on Saturday or Sunday.

[a]Values are different from those for 1994–1998, $p<0.05$.

[b]Values are different from those for 2013–2014, $p<0.05$.

FAH, food at home; FAFH, food away from home.

of each effect between 2005–2010 and 2011–2012 and between 2011–2012 and 2013–2014 was assessed.

All regressions examine how outcomes vary across survey years, controlling for sex, age group (5–10 years vs 11–14 years, and 15–19 years), race/ethnicity (non-Hispanic whites, non-Hispanic blacks, Hispanics, and other), household income (low income, middle income, and high income), and educational attainment of the household head (below high school, high school, attended college without a degree, and college degree).[32–34]

RESULTS

During 1994–2014, total grain intake was relatively stable as compared with whole grain intake among all schoolchildren (Table 1). Consequently, the ratio of whole grains to total grains in children's diets changed significantly over survey periods ($p<0.05$, F-test). Whole grain consumption at home fell significantly from 1994–1998 to 2003–2008 ($p<0.05$) but then recovered to a level comparable to 1994–1998 for the remaining years. Consumption of whole grains from restaurants and school remained constant during 1994–2008, then mirrored the trend in FAH consumption, and rose significantly in 2013–2014 ($p<0.05$). For example, the average whole grain consumption at school among all schoolchildren tripled from 0.06 ounces/day in 2011–2012 to 0.18 ounces/day in 2013–2014. Consequently, the ratio of whole grain to total grain consumption from school foods rose sharply from 4.35% in 2003–2004 to 8.60% in 2011–2012 before reaching 21.48% in 2013–2014. Among all sources, FAH was the richest in whole grains during 1994–2012 before giving way to school foods in 2013–2014 (17.16% vs 21.48%), when the 2012 school meal standards became effective (Table 1).

Regression results (Table 2) confirm that although schoolchildren's diets are far from meeting recommendations, the whole grain/total grain ratio significantly increased from 8.71% in 1994–1998 to 12.55% in 2013–2014. This increase was mainly due to whole grain intake from school, which increased from 0.02 ounces/day in 1994–1998 to 0.18 ounces/day in 2013–2014 (Table 1).

Consumption of whole grains varies by age, race and ethnicity, and the educational achievement of the household head but not by household income (Table 2). Focusing on children who ate school foods, older schoolchildren aged 11–14 and 15–19 years had diets less whole-grain dense than their younger counterparts. Schoolchildren had the most whole-grain dense diet for FAH when the household head was college educated. Compared with individuals of other race/ethnicity, diets of non-Hispanic white children were denser in whole grains for FAH but less dense in whole grains from school foods.

The logistic regression results (Table 3) were used to calculate the propensity to consume whole grains, among those who ate school meals using the mean values of their demographic characteristics (Appendix Table 2). Results show that leading up to the change in school meal standards, there was no significant change in the propensity to consume whole grains from school during 1994–2010, with propensities ranging from 0.142 to 0.200 (Figure 1A). However, in 2013–2014 students became more than twice as likely to consume whole grains from school as in any previous survey period with a propensity of 0.494—almost one in every two students eating school foods ate whole grains. Table 3 also shows the propensity to consume whole grains from school was lower among older children as compared with those aged 5–10 years ($p<0.05$), and by non-Hispanic white children as compared with non-Hispanic black and Hispanic children ($p<0.05$).

The intensity regression results (Table 3) are used to calculate the average consumption intensity among those who consumed whole grains from school in Figure 1B, again using the mean values of their demographic characteristics (Appendix Table 2). The average intake remained relatively stable over 1994–2010 (0.46 to 0.54 ounces/day) before significantly ($p<0.05$) increasing to 0.74 ounces/day in 2011–2012 and to 1.07 ounces/day in 2013–2014 (Figure 1B). Table 3 also shows for those who ate whole grains as a part of school-prepared foods, compared with their respective counterparts, a larger average amount was consumed among males, those aged 11–14 years, and those from high-income households. Non-Hispanic white schoolchildren consumed a smaller amount of whole grains from school foods than other children.

Because the whole grain recommendation first appeared in the 2005 DGAs, the decomposition analysis compared 2005–2010 vs 2011–2012, and then compared 2011–2012 vs 2013–2014. The idea was to disentangle the effects of propensity (Figure 1A), intensity (Figure 1B), and their interaction on the increasing trend of whole grain consumption at school. Figure 1C reports the change in whole grain consumption (ounces/day) over these two periods broken down by propensity, intensity, and the interaction effects. Figure 1D expresses each effect as a percentage of the total effect to show their relative contributions.

Between 2005–2010 and 2011–2012 the intensity of whole grain consumption from school significantly increased, but there was no significant change in the propensity to consume whole grains (Figures 1A and 1B). Using the mean values of consumption propensity and intensity, the intensity effect outweighs the propensity effect at a ratio of 1.18 (45.10% to 38.3%) during this

Table 2. Regression Results of Whole Grains/Total Grains Ratio (%) Among Schoolchildren: 1994–2014

Independent variable	All sources	FAH	FAFH	Restaurant	School	Other FAFH
Survey wave						
Year 1994–1998	**8.71[b] (0.76)**	**10.31[b] (1.28)**	**5.31[b] (0.85)**	**0.19[b] (0.99)**	**6.20[b] (1.20)**	10.44 (2.30)
Year 2003–2004	**6.70[a,b] (0.74)**	**9.14[b] (1.45)**	**5.23[b] (1.08)**	**1.29[b] (1.36)**	**4.46[a,b] (1.15)**	10.22 (2.58)
Year 2005–2006	**6.71[a,b] (0.96)**	**8.99[b] (1.64)**	**4.94[b] (0.88)**	**0.99[b] (1.19)**	**5.77[b] (1.23)**	8.32 (2.41)
Year 2007–2008	**7.83[b] (0.91)**	**9.75[b] (1.44)**	**5.07[b] (0.79)**	**1.32[b] (0.93)**	**5.73[b] (1.11)**	**6.86[a] (2.25)**
Year 2009–2010	**8.48[b] (0.74)**	**11.15[b] (1.30)**	**4.88[b] (0.88)**	**1.66[b] (1.30)**	**7.16[a,b] (1.30)**	**6.12[a,b] (2.04)**
Year 2011–2012	**10.58[a,b] (1.03)**	**14.38[a] (1.68)**	**7.03[a,b] (0.97)**	**1.53[b] (1.07)**	**10.95[a,b] (1.45)**	12.07 (2.53)
Year 2013–2014	**12.55[a] (1.04)**	**14.61[a] (1.59)**	**12.02[a] (1.25)**	**3.79[a] (1.16)**	**22.58[a] (1.84)**	9.87 (2.39)
Sex						
Female (ref)						
Male	0.01 (0.37)	−0.28 (0.61)	0.11 (0.45)	0.21 (0.62)	−0.79 (0.48)	−0.20 (0.77)
Age, years						
5–10 (ref)						
11–14	−0.64 (0.44)	−0.41 (0.67)	−0.40 (0.59)	**1.72[c] (0.84)**	**−2.18[c] (0.64)**	−2.01 (1.22)
15–19	**−1.78[c] (0.44)**	−0.67 (0.81)	**−2.28[c] (0.44)**	0.17 (0.57)	**−2.28[c] (0.77)**	**−4.50[c] (1.33)**
Race and ethnicity						
Non-Hispanic white (ref)						
Non-Hispanic black	−0.60 (0.47)	**−2.14[c] (0.78)**	1.07[c] (0.47)	−0.57 (0.42)	2.26[c] (0.78)	1.74 (1.43)
Hispanic	−0.76 (0.49)	**−2.25[c] (0.78)**	0.48 (0.46)	0.26 (0.63)	0.89 (0.71)	−0.65 (1.38)
Other race/ethnicity	−0.74 (0.75)	**−2.73[c] (1.24)**	0.91 (1.08)	−1.26 (0.67)	3.89 (2.00)	−0.02 (1.68)
Household income, % federal poverty guideline						
<185%	0.39 (0.60)	0.48 (1.04)	−0.25 (0.70)	0.12 (0.70)	−0.06 (0.83)	0.50 (1.81)
185%–300% (ref)						
>300%	0.06 (0.54)	1.02 (0.90)	−0.69 (0.78)	0.50 (0.73)	−1.26 (0.98)	−1.31 (1.65)
Weekday (ref)						
Weekend	−0.77 (0.40)	−0.55 (0.58)	**−1.27[c] (0.49)**	−0.12 (0.49)	6.00 (3.59)	0.27 (1.11)
Household head education						
Less than high school (ref)						
High school	0.41 (0.47)	1.44 (0.81)	−0.30 (0.67)	0.13 (0.71)	−1.13 (0.72)	0.36 (1.85)
Some college	**1.81[c] (0.53)**	**3.18[c] (0.80)**	−0.58 (0.60)	−0.12 (0.75)	0.23 (0.74)	1.42 (1.80)
College	**3.62[c] (0.68)**	**6.48[c] (1.01)**	−0.06 (0.74)	1.62 (0.86)	−0.64 (1.02)	−0.28 (1.76)

Note: Data are shown as Estimate (SE). Restaurant includes full-service restaurants and fast food places. Boldface indicates statistical significance ($p<0.05$). Coefficients for survey years represent the share of whole grains in total grains for the referent schoolchildren; the shares reported in Table 1 represent all schoolchildren.
[a]Values are significantly different from the year 1994–1998, $p<0.05$.
[b]Values are significantly different from the year 2013–2014, $p<0.05$.
[c]Values are significantly different from zero or their reference, $p<0.05$.
FAFH, food away from home, FAH, food at home.

period (Figure 1D). This ratio, however, drops to 0.41 (22% vs 54%) between 2011–2012 and 2013–2014. The interaction effect is the joint effect of propensity and intensity, which is greater than the intensity effect between 2011–2012 and 2013–2014 (24% vs 22%).

DISCUSSION

Since 2005, the U.S. federal government has recommend in its DGAs that whole grains account for at least half of total grain intake. In response, USDA-funded school meals now incorporate this recommendation as a basis for federal reimbursements. Starting in the 2012–2013 school year, at least half of all grains offered as a part of USDA-funded lunches were required to be whole grain–rich, defined as containing at least 50% whole grain.[35] In 2013–2014, this requirement was extended to USDA-funded breakfasts. At the time of the 2005 DGAs' recommendation, 7.6% of schoolchildren's grain intake was whole grain. Since then, the ratio of whole grain to total grain consumption steadily increased, reaching 13.5% in 2013–2014.

This study documents an increasing trend in whole grain consumption across all food sources. Between 1994–1998 and 2011–2012 the whole grain/total grain ratio was highest for FAH. In 2013–2014, for the first

Table 3. Logistic and Intensity Regression Results for Whole Grain Consumption From School Among Those Who Ate School Foods, 1994–2014

	Logistic (propensity)		Intensity
Independent variable	**Coefficient (SE)**	**OR**	**Coefficient (SE)**
Survey wave			
Year 1994–1998	**−1.655[a,c] (0.237)**	0.191	**0.379[a,c] (0.037)**
Year 2003–2004	**−1.460[a,c] (0.318)**	0.232	**0.321[a,c] (0.011)**
Year 2005–2006	**−1.835[a,c] (0.261)**	0.160	**0.372[a,c] (0.012)**
Year 2007–2008	**−1.587[a,c] (0.246)**	0.204	**0.366[a,c] (0.012)**
Year 2009–2010	**−1.420[a,c] (0.270)**	0.242	**0.416[a,c] (0.013)**
Year 2011–2012	**−1.205[a,c] (0.290)**	0.300	**0.612[a,c] (0.012)**
Year 2013–2014	−0.024 (0.252)	0.977	**0.948[a] (0.012)**
Sex			
Female (ref)			
Male	0.024 (0.098)	1.024	**0.093[a] (0.006)**
Age, years			
5–10 (ref)			
11–14	**−0.462[a] (0.111)**	0.630	**0.091[a] (0.005)**
15–19	**−0.351[b] (0.147)**	0.704	**−0.032[a] (0.004)**
Race and ethnicity			
Non-Hispanic white (ref)			
Non-Hispanic black	**0.487[a] (0.139)**	1.628	**0.108[a] (0.009)**
Hispanic	**0.269[b] (0.127)**	1.309	**0.140[a] (0.006)**
Other race/ethnicity	0.263 (0.248)	1.301	**0.149[a] (0.026)**
Household income, % federal poverty guideline			
<185%	0.140 (0.167)	1.150	−0.009 (0.008)
185%–300% (ref)			
>300%	−0.221 (0.180)	0.801	**0.056[a] (0.015)**
Household head education			
Less than high school (ref)			
High school	−0.111 (0.175)	0.895	−0.027 (0.015)
Some college	0.104 (0.150)	1.110	**0.030[a] (0.006)**
College	−0.012 (0.202)	0.988	**−0.087[a] (0.016)**
Sample size	4,788		1,172
R-squared			0.59
Correct predictions	76.3%		

Note: Correct predictions indicate the percent of observations which correctly predict the outcome using the predicted probability of 0.5 as the threshold. The two regression models are estimated twice by (1) treating the 2013–2014 survey wave as the base so that the coefficients for previous waves can be tested against 2013–2014 and (2) including all waves of seven surveys and dropping the constant term, as reported in the table. Boldface indicates statistical significance ($p<0.05$).

[a]Values are significantly different from zero (i.e., survey wave) or their reference, $p<0.01$.

[b]Values are significantly different from zero (i.e., survey waves) or their reference, $p<0.05$.

[c]Values are significantly different from the 2013–2014 coefficients, $p<0.01$.

time, the ratio was higher for foods obtained at school as compared with FAH (17.3% versus 21.5%), reflecting the new school standards.[11] Note that each WWEIA survey ran from November 1 of the odd year through October 31 of the even year. Thus, the WWEIA 2011–2012 contained 2–3 months of the 2012–2013 school year, while the WWEIA 2013–2014 data were fully covered under the new school meal standards.

The aforementioned increases in whole grain consumption from school was decomposed into the propensity to consume (proportion of students consuming whole grains), intensity of consumption (amount consumed by whole grain consumers), and their joint effect. Results indicate that increases leading up to the 2011–2012 level were primarily driven by increased whole grain consumption among those who consumed (intensity). During this period, it may have been that some school foodservices voluntarily enriched the whole grain content either in response to DGAs' advice or to meet local preferences. Conversely,

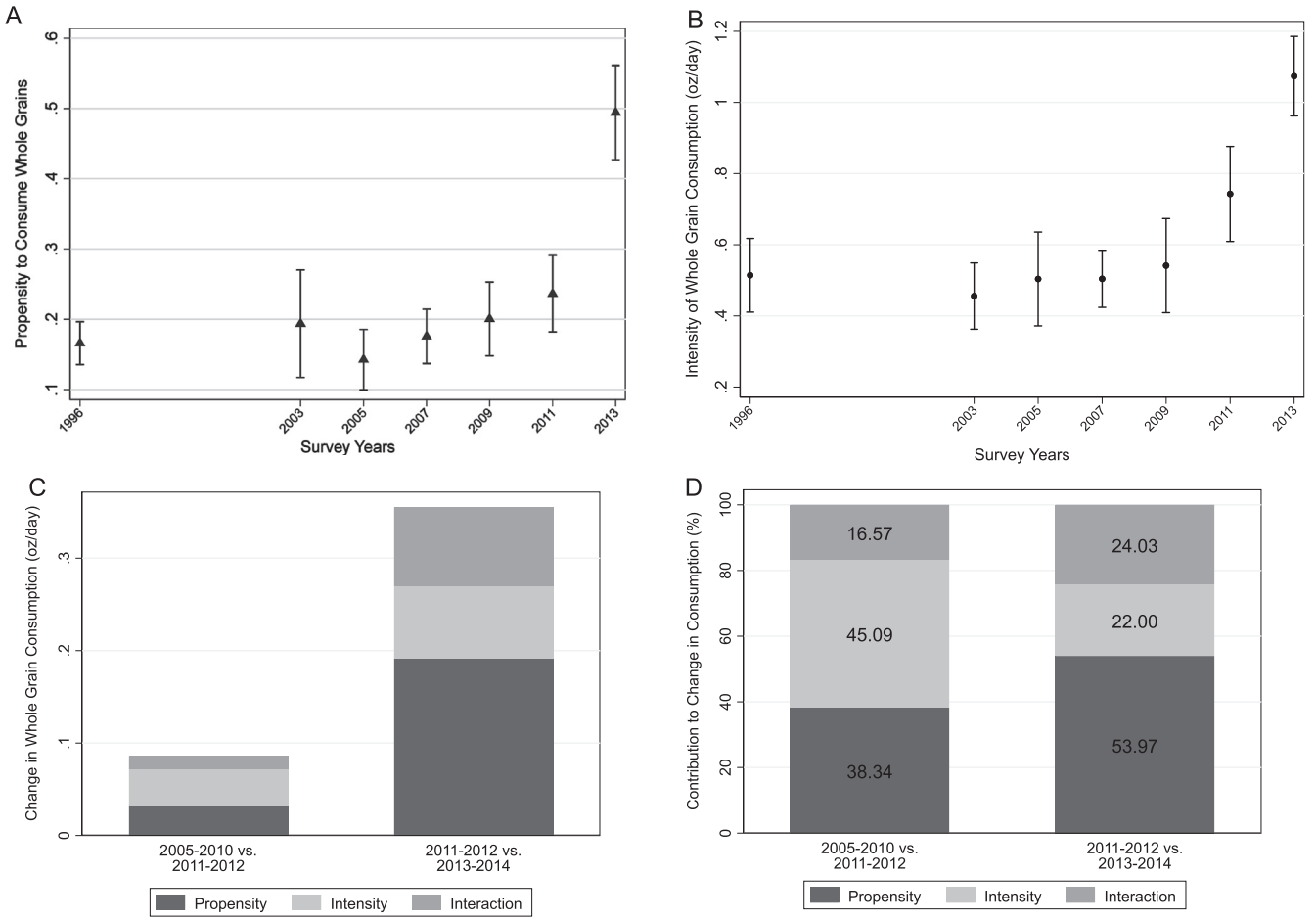

Figure 1. Changes in the propensity and intensity of whole grain consumption from school, among schoolchildren aged 5–19 years who ate school meals: 1994–2014.

Note: All numbers depicted in the figure are for the sample of children who ate school meals (Appendix Table 2). Propensity (triangle, panel A) is the probability of consuming any whole grains from school. Intensity (circle, panel B) is the amount of whole grains (ounces/day) consumed from school among those who consumed whole grains from school. Vertical bars in panels A and B represent 95% CIs. Panel C decomposes the change in whole grain consumption (ounces/day) from school over survey waves into propensity, intensity, and the interaction effects (Appendix Text). Panel D depicts the percentage (%) of the total change attributable to propensity, intensity, and the interaction effect. All analyses used survey weights and account for the complex survey design.

the marked increase in whole grain consumption from 2011–2012 to 2013–2014 was primarily attributable to an increase in the numbers of students consuming whole grains from school foods (propensity), rather than an increase in amounts consumed (intensity), although both were contributing factors. The increase in consumption propensity is similar to previous findings by Cullen and colleagues,[21] but unlike them, this study also found an increase in consumption amounts, albeit smaller. Although this study cannot ascribe causality, these findings strongly suggest that the nationwide inclusion of whole grains in school menus has reached a large number of Americans. Supporting this inference, a recent nationwide study of 5,106 children found a positive association between school breakfast participation and whole grain intakes.[36]

For school foods, the whole grain/total grain ratio for non-white children was higher than that observed for white children. This was the opposite of the finding for FAH foods. Note that the school foods grouping includes both USDA school meals and non-USDA foods sold at school, which may be less nutritious—although in 2014–2015, schools participating in the National School Lunch Program were required to meet higher nutrition standards for all foods they sell.[35] White children are somewhat less likely to participate in school meals than other children,[37] making it possible that non-USDA foods may have played a larger role in their school food consumption, although this study is not able to separate USDA and non-USDA foods. The difference in the relationship of race and ethnicity to whole grain intake from school foods versus home foods does,

however, suggest the value of multiple strategies for implementing dietary advice.

Although these results are encouraging, this study finds that 22% of grain consumption from school foods was whole grain, indicating considerable room for improvement. Beginning in the 2014–2015 school year, the 2012 school meal standards[11] required all grains served as part of USDA meals to be whole grain–rich. However, many school foodservices argued that this has posed hardships because of limited availability of products and lack of student acceptance.[38] Consequently, exemptions for certain food products were granted through the 2018–2019 school year as part of a rule offering flexibilities for meeting National School Lunch Program requirements,[38] and in the finalized rule on flexibilities, effective as of school year 2019–2020, the USDA required that only half of grains offered be whole grain–rich.[39] Further improvements in whole grain intake from schools may depend on further developments of new, appealing, whole grain products tailored to school foodservices[40] coupled with effective strategies to foster acceptance.

School meals have strong potential to foster healthier food preferences. Research has established that food preferences are largely shaped by repeated exposure.[41] The requirement to routinely offer whole grain–rich foods at school may provide this repeated exposure, but does not guarantee consumption. Appealing products, served in a comfortable environment with adequate time to eat,[42] accompanied by such strategies as taste tests, modeling by teachers and other role models, and promotion of social norms favoring healthy foods may encourage regular consumption.[43] Such strategies could be particularly beneficial to low-income students who make up the majority of USDA school meal participants,[14] because their parents may consider it too costly to purchase healthy items their children may ultimately reject.[44]

Improving acceptance at school may have effects beyond the meals themselves. Some research suggests USDA-sponsored fruit and vegetable snack programs have increased the preference for and consumption of these foods outside of school.[45,46] Other research has indicated that food consumption patterns established in childhood track into later childhood and adolescence.[47,48] Further research should investigate how whole grain intake from school is associated with consumption in other locations and with consumption later in life.

Limitations

The cross-sectional nature of the data does not permit causal inference. The databases used may not perfectly capture the whole grain content of all foods. Although the surveys' dietary intake methodology has been validated, recalls may be limited by an individual's ability to describe consumed foods accurately. Finally school foods may include items obtained at school but not part of USDA meals. Nevertheless, analysis of these large nationally representative data sets provides important information on the extent to which whole grain intakes of schoolchildren have changed over time and the association with federal policy and programs.

CONCLUSIONS

Between 1994 and 2006, children's diets became less whole grain–dense. Federal recommendations published in 2005 may have helped to reverse this decline through their impacts on both foods prepared at home and foods obtained from school. Importantly, in 2012, USDA school meals were required to include whole grain–rich items, after which school foods became the most whole grain–dense source in schoolchildren's diets. This change was associated with both a larger percentage of children obtaining whole grains at school, as well as consumption of larger quantities of whole grains, demonstrating a broad-based impact on children's diets.

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Smith and Lin prepared the data; Lin did the statistical analyses; and Lin, Guthrie, and Smith together interpreted the results, prepared the manuscript, and responded to reviewers' comments.

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SUPPLEMENTAL MATERIAL

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