Fruits and Vegetables Versus Vegetables and Fruits: Rhyme and Reason for Word Order in Health Messages

Abstract: Both vegetable and fruit consumption contribute to wellness and disease prevention. Most dietary health messages promote both together and position the word “fruits” before “vegetables.” We examined the word order of the commonly used phrase “fruits and vegetables” through linguistics, psychology, botany, nutrition, health outcomes, and current US intake to determine if the common word order best presents these two foods in health messaging. By comparing the 10 most commonly consumed vegetables versus fruits, we found that vegetables scored higher on the Aggregate Nutrient Density Index and contained fewer calories and more fiber than fruits. Among the “nutrients of public concern” listed in the 2015 Dietary Guidelines for Americans, we determined that vegetables are better sources of these nutrients than fruits, although fruits scored higher in antioxidant content. In observational cohort studies, vegetable and fruit consumption was found to be associated with decreased mortality. Finally, daily intakes of both vegetables and fruits are lower than recommended, but the discrepancy is larger for vegetables—

especially among children—suggesting a greater imperative to promote vegetables. For these reasons, future health messages promoting both together should intentionally put “vegetables” first to promote intake and emphasize their importance regarding contribution to health.

Keywords: word order; health messages; fruit and vegetable; vegetable and fruit; nutrition

recommendations. The US Department of Agriculture (USDA) created separate vegetable and fruit groups in 1984 for the *Food Wheel: A Pattern for Daily Food Choices* prepared for the Red Cross.³ The original USDA Food Pyramid,⁴ MyPyramid.gov,⁵ and the most recent, MyPlate.gov,⁶ all have separate vegetable and fruit groups.³ However, many other public health messages still combine the two and list “fruits” first. Examples include the Centers for Disease Control

Is there a return to vegetable rapture in health messaging, or is it just random word choice to put vegetables first in these situations?

Introduction

Intake of vegetables and fruits is promoted by several US government and national health agencies to support optimal health.^{1,2} Versions of US food guides published between 1940 and 1970 referred to the “vegetable and fruit group” as part of the daily diet

and Prevention (CDC) *Five-a-Day*⁷ program and its successor, *Fruit and Veggies: More Matters*.⁸ Similarly, in a search of scientific literature indexed in MEDLINE using PubMed.gov we found six to eight times more English language articles published over the past 10 years with “fruits and vegetables” in their titles versus “vegetables and fruits.”

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However, a trend of listing “vegetables” first appears to have emerged recently in some public health messaging. The *Nutrition Source*, Harvard T. H. Chan School of Public Health’s nutrition information website, refers to “vegetables and fruits” as part of a healthy diet.⁹ The 2015 Dietary Guidelines for Americans emphasize that Americans should increase their intake of “vegetables and fruits.”² One of Healthy Canada’s public health messages is to eat more “vegetables and fruits.”¹⁰ Is there a return to vegetable rapture in health messaging, or is it just random word choice to put vegetables first in these situations? The aim of this project was to explore rationales for word order, including linguistics, psychology, botany, nutrition, health outcomes, and the alignment of current US intake with US recommendations for intake, to determine whether there were compelling reasons to think that vegetables squash fruits and should be put first in the word order of health messages.

The Linguistics of Food

In many languages, the order of words can change the meaning of the sentence, or just show the importance of one over the other. “Fruits and vegetables” is a common binomial in the English language, where the word order is predictable. A binomial is a sequence of two words from the same word class that are linked by a conjunction and are usually said in the same order.¹¹ The word order of binomial expressions typically follows set linguistic standards, although these rules are debated by linguists.^{12,13} The order of some common binomials in the English language can be predicted from rhythm (eg, “peas and carrots”), length of the words (eg, “oil and vinegar”), or both the combination of length and position of the stressed syllable (eg, “salt and pepper”). Word order that utilizes alternating rhythm between the stress syllables of binaries is more common than word order with an irregular pattern of syllable stressing.¹⁴ In this example, “fruits and vegetables” has

a shorter space between the stressed syllables of the words than “vegetables and fruits.” Mollin¹² and Malkiel¹⁵ both suggest that the reason for the order of binomials in language can be simply that the first word has fewer syllables than the second as in “rich and famous,” and “time and money.” From a linguistics perspective, binomial word order is partially dependent on metrics, rhythm, and count of syllables; therefore, the word order “fruits and vegetables” simply sounds better when “fruits” is said first.

Psychology of Word Order

Psychologists have found the predictability of word order in multiword phrases influences their persistence in memory and that by processing an unfamiliar phrase, the reader must think about it for more time.¹⁶ Similarly, unfamiliar binomial phrases and garden path statements (eg, “Time flies like an arrow; fruit flies like a banana”) often need to be read more than once in order to understand their meaning.¹⁷ This additional processing time, measured as an event-related potential in the brain known as P600, is elicited when the brain requires more thought resources to understand the inconsistency in the actual versus the expected word order in a phrase.¹⁸ The cognitive load of processing an unfamiliar phrase can also be explained by Levy’s Surprisal Theory,¹⁹ where a flipped binomial like “vegetables and fruits” may provide enough of a surprise to the reader to require more processing time and, therefore, may become more entrenched in memory. Could this change in the familiar order of words in a commonly heard public health message be the proverbial carrot that entices American consumers to think twice about their food intake preferences?

Botany of Vegetables Versus Fruits

An issue of relevance to add to this discussion is the confusion regarding the

distinction between what constitutes a vegetable versus a fruit in the United States.²⁰ The confusion typically arises from differences between culinary versus botanical classifications. Foods that fall into the culinary classification of *vegetable* include both botanical vegetables as well as some botanical fruits (eg, bell peppers, tomatoes, and eggplant). To clarify this distinction, it is informative to look through the lens of plant anatomy.

Botanically, a fruit is the reproductive outcome of floral pollination and is the ripened ovary of flowering plants. The term *fruit* defines those foods humans use as food and recognize as fruits, such as an apple, but scientifically is the result of a plant’s resources to ensure the proliferation of their particular plant species. Plants create the fruits we eat as a means to disseminate seeds using animals. Frugivore animals will smell the ripe fruit, ingest it, and then travel around and deposit the seeds elsewhere after the flesh of the fruit is digested.

The word *vegetable* originates from the growth of the vegetative parts of the plant that are of the plant’s body and are not the result of floral pollination. For example, the potato is actually a stem tuber that grows underground and is a source of nutrition for the plant; it is, thus, considered a storage organ. A carrot is the taproot of the entire plant, and onions are bulbs or short stems with fleshy leaves—both of which are also storage organs. Lettuce is the entire plant, and celery includes the stalks of the entire plant body. Broccoli, Brussels sprouts, and kale are all the same species but different cultivars or breeds of *Brassica oleracea* that were selected for their specific vegetable offerings: Brussels sprouts are small, densely leaved buds; broccoli has thick stems with abundant stalks holding many little flowers; kale has large edible leaves; and all have the beneficial phytochemicals found in cruciferous vegetables.²¹ All vegetables are from parts of the plant body itself and not the result of plant reproduction efforts that result in a seed-dispersal organ or a fruit.

A classic example illustrating the public confusion of vegetables and fruits is the tomato. Tomatoes—the second most consumed vegetable in the United States²²—are botanically fruit, yet most people consider them a vegetable. In 1883, the tomato was the center of a court decision involving taxes—vegetables were taxed, whereas fruits were not. The plaintiff from the West Indies was selling tomatoes as fruit to avoid this tax. It was legally decided that tomatoes are, in fact, vegetables in the light of tariffs and common speech²³: law 1, botany 0! Therefore, tomatoes are legally categorized as vegetables, whereas other botanical fruits (eg, peppers, cucumbers, eggplant, and olives) are classified as vegetables because of their culinary uses and savory flavors.

The botanical guidelines for characterizing produce as vegetable, fruit, or other (eg, grains, tubers, or stems) can be confusing to nonbotanists. However, for botanists, it is clear which are true vegetables and fruits. Given that the average consumer of vegetables and fruits is not a botanist, we will use culinary classifications rather than botanical guidelines to distinguish between the two.

Contrasting Commonly Consumed Vegetables and Fruits

Consideration of the nutrients that people receive when consuming their favorite vegetables and fruits is one way to rationalize which of these botanical wonders—vegetables or fruits—should come first in public health messages. Table 1 lists the top 10 vegetables and fruits consumed by weight in the United States each year as reported by the USDA.²⁴

For the purpose of comparison, we considered serving size and energy content (ie, Calories, or kilocalories [kcal]). Serving sizes vary depending on which US governmental agency you ask. We used Nutrition Labeling and Education Act (NLEA) servings as set by the US Food and Drug Administration²⁵

Table 1.

The 10 Most Commonly Consumed Vegetables and Fruits in the United States.

Vegetables/Fruits	Pounds/Capita/Year (Loss Adjusted)
Vegetables	
Potatoes	26.8
Tomatoes	12.7
Onions	7.9
Iceberg lettuce	7.3
Green bell pepper	4.3
Carrots	4.0
Cabbage	3.1
Cucumbers	2.7
Celery	2.6
Broccoli	2.5
Fruits	
Banana	10.3
Apples	9.9
Watermelon	4.3
Grapes	4.2
Strawberries	3.8
Oranges	3.4
Avocado	1.9
Peaches	1.7
Pears	1.6
Mangoes	1.1

because these represent commonly eaten food portions. Some foods included in the analysis did not have NLEA serving sizes established, so the authors estimated serving size based on USDA serving sizes.²⁶ There are different serving sizes for each type of food. Given that serving sizes vary, we also analyzed the nutrient content of 100 kcal portions of each vegetable and fruit to make sure that we were comparing broccoli to broccoli and apples to apples.

Table 2 presents the specific serving sizes used in the analyses. Additionally, we compared the nutrients per serving, 100 kcal, and 100 g for the top 15 and top 25 consumed vegetables and fruits (by weight) as well as all vegetables and fruits for which at least 1 pound per capita per year was eaten in the United States. We found a similar pattern when examining per serving, 100 kcal, or 100 g whether we looked at the top 10, 15, or 25 most commonly consumed vegetables

Table 2.

Nutrient Levels in the 10 Most Commonly Consumed Vegetables and Fruits Per 100 Calories.

	Serving Size (g)	Serving Size (Approximate)	Total Sugar (g)	Total Fiber (g)	Vitamin A (IU)	Vitamin C (mg)	Folate (µg)	Iron (mg)	Magnesium (mg)	Calcium (mg)	Potassium (mg)	ANDI Index
Vegetable												
Potatoes	116.00	1 Small baked	0.99	2.38	3.00	8.58	10.00	0.36	23.00	9.00	380.00	43.00
Tomatoes	554.50	3 Large	14.58	6.65	4619.00	75.97	83.00	1.50	61.00	55.00	1314.00	186.00
Onions	251.00	2 Medium	10.64	3.67	5.00	18.57	48.00	0.53	25.00	58.00	366.00	109.00
Iceberg lettuce	711.50	1½ Heads	14.02	8.54	3572.00	19.92	206.00	2.92	50.00	128.00	1003.00	110.00
Green bell pepper	500.00	3 Large	12.00	8.50	1850.00	402.00	50.00	1.70	50.00	50.00	875.00	371.00
Carrots	243.00	4 Medium	11.52	6.80	40,596.00	14.34	46.00	0.73	29.00	80.00	778.00	458.00
Cabbage	399.00	Half medium head	12.77	8.94	391.00	146.03	172.00	1.88	48.00	160.00	678.00	434.00
Cucumbers	664.00	2 Large	11.09	7.57	697.00	18.59	46.00	1.86	86.00	106.00	976.00	87.00
Celery	624.50	10 Large stalks	11.43	9.99	2804.00	19.36	225.00	1.25	69.00	250.00	1624.00	135.00
Broccoli	293.00	2 Stalks	4.98	7.62	1825.00	261.36	185.00	2.14	62.00	138.00	926.00	340.00
Mean	435.65		10.40	7.10	5636.20	98.50	107.10	1.49	50.30	103.40	892.00	227.30
SEM	64.70		1.30	0.80	3915.40	42.40	25.40	0.30	6.40	21.90	121.70	49.50
Fruit												
Banana	112.50	1 Medium	13.76	2.93	72.00	9.79	23.00	0.29	30.00	6.00	403.00	30.00
Apple	192.00	1 Medium	19.95	4.61	104.00	8.83	6.00	0.23	10.00	12.00	205.00	53.00

(continued)

Table 2. (continued)

	Serving Size (g)	Serving Size (Approximate)	Total Sugar (g)	Total Fiber (g)	Vitamin A (IU)	Vitamin C (mg)	Folate (µg)	Iron (mg)	Magnesium (mg)	Calcium (mg)	Potassium (mg)	ANDI Index
Watermelon	333.30	2¼ Cups diced	20.67	1.33	1896.00	27.00	10.00	0.80	33.00	23.00	373.00	71.00
Grapes	145.00	1½ Cups	22.45	1.31	96.00	4.64	3.00	0.52	10.00	15.00	277.00	119.00
Strawberries	313.00	1 Pint	15.31	6.26	38.00	184.04	75.00	1.28	41.00	50.00	479.00	182.00
Orange	212.00	1½ Oranges	19.82	4.98	477.00	112.78	64.00	0.21	21.00	85.00	384.00	98.00
Avocado	60.00	Half avocado	0.18	4.08	88.00	5.28	53.00	0.37	17.00	8.00	304.00	28.00
Peach	256.00	2 Small	21.48	3.84	835.00	16.90	10.00	0.64	23.00	15.00	486.00	65.00
Pear	175.00	1 Medium	17.06	5.53	44.00	7.53	12.00	0.32	12.00	16.00	203.00	46.00
Mango	166.70	1 Cup pieces	22.77	2.67	1804.00	60.68	72.00	0.27	17.00	18.00	280.00	53.00
Mean	196.60		17.30	3.75	545.40	43.80	32.80	0.49	21.40	24.80	339.40	74.50
SEM	27.00		2.10	0.53	231.80	19.00	9.40	0.10	3.30	7.70	32.20	14.90
<i>t</i> Value ^a	-3.41		2.76	-3.60	-1.30	-1.18	-2.74	-3.65	-4.00	-3.38	-4.39	-2.95
<i>P</i> value ^b	0.01		0.01	<0.01	0.23	0.26	0.02	<0.01	<0.01	0.01	<0.01	0.01

Abbreviations: ANDI, Aggregate Nutrient Density Index; SEM, standard error of the mean.

^aPositive *t* values indicate higher mean difference value for fruit compared with vegetables; negative *t* values indicate higher mean difference for vegetables compared with fruit.^b*P* values from *t*-test; they are bolded if $\leq .05$.

and fruits. Therefore, for ease of presentation we chose to display the analysis for only the top 10 in Table 2.

Another option considered for analysis was to exclude white potatoes from vegetables (because they are classified as a starch in USDA's MyPlate and often eaten as a fried food), iceberg lettuce from vegetables (because they are widely recognized for lack of significant nutritional content), and avocados from fruits (because they are not considered a fruit by culinary classification). However, we did not want to be accused of cherry-picking, so all three remained in our final analyses.

Nutrient Density of Vegetables and Fruits

Increasing both vegetable and fruit intake is a nearly universal dietary recommendation. Prioritizing one over the other to optimize health could be based on nutrient density or other nutrient quality scores. These scores can be a useful way to distinguish which foods pack the most nutritional punch.

Two scores that have been used to rank foods are the Aggregate Nutrient Density Index (ANDI) and NuVal scores. The ANDI score divides the total nutrients in the food by the number of calories per serving; it includes 35 vitamins and minerals as well as other nutrients such as fiber, antioxidants, phytosterols, angiogenesis inhibitors, and resistant starches in its algorithm.²⁷ The ANDI score ranges from 1 to 1000, with 1000 being the most nutritious. The NuVal Score is based on an algorithm of the *Overall Nutritional Quality Index* to measure 30 different nutrients (including vitamins, minerals, bioflavonoids, and carotenoids), protein quality, fat quality, glycemic load, and energy density. The NuVal score rates foods from 1 to 100, with 100 being the most nutritious.²⁸ Unlike the ANDI score, the NuVal score also detracts for trans fat, cholesterol, saturated fat, sodium, and sugar.

Comparison of the ANDI scores for the top 10 consumed vegetables and fruits are shown in Table 2. Carrots rooted out the most nutrients of the vegetables at 458, whereas strawberries topped the

fruits at a juicy 182. Overall, vegetables significantly outperformed fruits: 227 ± 50 versus 74 ± 15 (mean $\pm$ SEM); $P = 0.014$. The NuVal scoring system gives all whole plant foods near perfect scores. Therefore, all the vegetables and fruits included in the analyses had nearly identical NuVal scores (all >90) and are not shown in the table.

Selected Nutrients in Vegetables and Fruits

Daily intake of vegetables and fruits provides vital vitamins and minerals. The 2015 Dietary Guidelines for Americans recommends vegetables as a source of nutrients such as potassium, vitamin A, vitamin C, vitamin K, copper, magnesium, vitamin E, vitamin B₆, folate, iron, manganese, thiamin, niacin, and choline. It recommends fruit as a source of dietary fiber, potassium, and vitamin C.² Some nutrients currently considered more important and challenging to get in the American diet include vitamins A and C, folate, calcium, iron, magnesium, and potassium.¹ Eating both vegetables and fruits provide these specific nutrients of concern.

The amounts of these specific nutrients in each of the 10 most commonly consumed vegetables and fruits are presented in Table 2. Per 100 kcal, vegetables contained significantly more folate, iron, magnesium, calcium, and potassium than fruit. However, when compared per serving, no statistically significant differences between vegetables and fruits were found for any of these nutrients. Table 2 presents only the 100-kcal data in the table to show these differences, where present.

Fiber in Vegetables Versus Fruits

As presented in Figure 1, there are differences in the total fiber content of the vegetables and fruits analyzed. By 100-kcal portions, the vegetables had nearly double the fiber (7.8 g) of the fruits (3.8 g); however, per serving, there was no statistically significant difference in fiber between vegetables and fruits. Notably, 100 kcal of vegetables is, on average, a larger serving than 100 kcal of

fruit. This difference is primarily a result of the higher sugar, and therefore higher calorie, content of fruit (15.0 g) compared with vegetables (2.8 g) per standard serving.

Antioxidant Content of Vegetables Versus Fruits

Both vegetables and fruits are good sources of antioxidants but vary in the strength of their antioxidant activity. Two common tests of total antioxidant activity of plants are the oxygen radical absorption capacity (ORAC) assay²⁹ and the measurement of total phenolics (a specific type of antioxidant). The ORAC score is shown in micromoles of Trolox Equivalence per 100 g ($\mu\text{mol TE}/100\text{ g}$) where Trolox is the standard for measurement of antioxidant power. Total phenolics are measured against Gallic Acid Equivalents (GAE), which uses gallic acid as the standard phenol.^{29,30} Published values for both measurements are available for 100-g portions.³⁰ For the top 10 addressed in these analyses, fruits have, on average, more than double the ORAC score of vegetables³⁰: 1875 ± 375 TE/100 g (mean $\pm$ SEM) for fruits compared with 733 ± 124 TE/100 g for vegetables. However, scores for total phenolic content are not as divergent (158 ± 26 [mean $\pm$ SEM] for fruits vs 109 ± 31 GAE/100 g for vegetables). For fruits, strawberries had the most of phenolics (332 mg GAE/100 g) and the highest ORAC score of 4302 $\mu\text{mol TE}/100\text{ g}$. Broccoli was at the head of the vegetable list with an ORAC score of 1510 $\mu\text{mol TE}/100\text{ g}$ and 316 mg GAE/100 g of phenolics.³⁰

Associations of Vegetable and Fruit Intake With Mortality in Cohort Studies

A literature review was conducted to search for studies that reported all-cause mortality as well as mortality findings related to cardiovascular disease (CVD), diabetes, or cancer and their associations with vegetable and fruit consumption. Relevant publications were identified by conducting a PubMed search for the

Figure 1.

Dietary fiber in vegetables and fruits per serving and by 100 kcal.

following terms in the title and abstract fields “(fruit intake[Title/Abstract] OR fruit consumption[Title/Abstract]) AND (vegetable intake[Title/Abstract] OR vegetable consumption[Title/Abstract]) AND (cancer[Title/Abstract] OR diabetes[Title/Abstract] OR cardiovascular[Title/Abstract] OR heart[Title/Abstract]) AND (morbidity[Title/Abstract] OR mortality[Title/Abstract]),” and by reviewing the reference sections of the identified studies as well as relevant reviews and meta-analyses. To be included, studies had to be prospective cohort studies with >1000 participants and present associations for total mortality and mortality related to each condition separately for vegetable and fruit intake.^{31–43} Of 30 publications initially identified by the search protocol, 13 publications comprising 15 international cohorts met the inclusion criteria. Excluded were review studies ($n = 2$), cohort studies with fewer than 1000 participants ($n = 1$), duplicative studies ($n = 1$), and studies that either did not report results for total mortality or disease-related mortality or did not report these results separately for vegetable and fruit intake ($n = 11$).

Overall, both vegetable and fruit intakes were linked to lower all-cause, CVD, stroke, and cancer mortality; however, the studies reported significant inverse associations of mortality with vegetable consumption more frequently than with fruit consumption. In Table 3, a significant association between vegetable or fruit intake and mortality was noted only when researchers reported a continuous statistically significant association between mortality and portions or servings of vegetable or fruit consumption.

In all, 10 studies found a statistically significant inverse association with mortality for vegetable intake.^{31,33,34,37–43} One of the studies observed a significant, but nonlinear, trend.³⁴ Specifically, vegetable intake was associated with lower all-cause, cancer, stroke, ischemic heart disease, and CVD mortality. Among these studies, four did not find an association between fruit intake and mortality.^{31,34,39,43} In contrast, eight studies found a statistically significant inverse association of mortality with fruit intake.^{32,33,35,37,38,40–42} Specifically, fruit intake was associated with lower all-cause, cancer, stroke, ischemic heart disease, and CVD mortality. Among these

studies, 2 did not find an association between vegetable intake and mortality.^{32,35} One study did not find a statistically significant association between mortality and either vegetable or fruit intake.³⁶

Among the five studies reporting on vegetable subgroups, two studies found a benefit for “salad vegetables” (eg, leafy salads, cucumbers, and tomatoes).^{33,41} One study each found a benefit for “green leafy vegetables,”³⁶ cooked and raw vegetables,³⁷ and “cruciferous vegetables” (eg, bok choy, cabbage, cauliflower, and turnip⁴²). Of the three studies reporting on fruit subgroups, none reported associations with specific fruits or types of fruits.^{35,36,41} Results presented here were limited by the individual food categories investigated by researchers in these articles.

Overall, the studies identified in this literature review reported more significant inverse associations between total and disease-related mortality for vegetable versus fruit consumption. However, most studies found intake of both vegetables and fruits to be beneficial, suggesting that both are associated with a mortality benefit.

Table 3.

Associations of Vegetable and Fruit Intakes With Mortality in Cohort Studies.

Authors	Sample Size	Cohort	Method	Follow-up (Years)	Mortality Outcomes	Vegetable Consumption and Protective Associations	Fruit Consumption and Protective Associations	Summary
Bellavia et al, 2013 ³¹	71 706	The Cohort of Swedish Men and the Swedish Mammography Cohort were combined	FFQ	Mean 13	<ul style="list-style-type: none"> All-cause (n = 11 439) 	All-cause	None	<ul style="list-style-type: none"> Vegetables, yes Fruit, very limited
Buil-Cosiales et al, 2014 ³²	7216	Prevención con Dieta Mediterránea (PREDIMED), Spain	FFQ	Mean 5.9	<ul style="list-style-type: none"> All-cause (n = 425) Cancer (n = 169) CVD (n = 103) 	None	All-cause	<ul style="list-style-type: none"> Vegetables, no Fruit, yes
Cox et al, 2000 ³³	3389	British Health and Lifestyle Survey (HALS1, 1984-1985) (HALS2, 1991-1992)	FFQ	6-8	<ul style="list-style-type: none"> CVD (n = 161) Cancer (n = 126) 	<ul style="list-style-type: none"> Men, CVD and cancer Women, CVD 	<ul style="list-style-type: none"> Men, no Women, CVD 	<ul style="list-style-type: none"> Vegetables, yes Fruit, yes Women only
Choi et al, 2015 ³⁴	14 198	Seoul Male Cohort Study	FFQ	Mean 15.6	<ul style="list-style-type: none"> Cancer (n = 507) 	Men, cancer	None	<ul style="list-style-type: none"> Vegetables, yes Fruit, no
Hertog et al, 1996 ³⁵	2112	The Caerphilly Study, Wales	FFQ	Mean 13.8	<ul style="list-style-type: none"> Cancer (n = 114) 	None	Men, cancer	<ul style="list-style-type: none"> Fruit, yes Vegetables, no
Hung et al, 2004 ³⁶	71 910	Nurses' Health Study	FFQ	Mean 13	<ul style="list-style-type: none"> CVD (n = 1964) Cancer (n = 6584) Other (n = 781) 	None	None	<ul style="list-style-type: none"> Fruit, no Vegetables, no
Hung et al, 2004 ³⁶	37 725	Health Professionals' Follow-Up Study	FFQ	Mean 13	<ul style="list-style-type: none"> CVD (n = 1670) Cancer (n = 2500) Other (n = 787) 	None	None	<ul style="list-style-type: none"> Fruit, no Vegetables, no
Leenders et al, 2014 ³⁷	451 151	European Prospective Investigation into Cancer and Nutrition study (EPIC)	Country-specific dietary questionnaire	Mean 13	<ul style="list-style-type: none"> All-cause (n = 25 682) CVD (n = 5125) Cancer (n = 10 627) 	<ul style="list-style-type: none"> CVD Cancer 	None ^a	<ul style="list-style-type: none"> Vegetables, yes Fruit, limited

(continued)

Table 3. (continued)

Authors	Sample Size	Cohort	Method	Follow-up (Years)	Mortality Outcomes	Vegetable Consumption and Protective Associations	Fruit Consumption and Protective Associations	Summary
Nagura et al, 2009 ³⁸	59 485	Japan Collaborative Cohort Study for Evaluation of Cancer Risk	FFQ	Mean 12.7	<ul style="list-style-type: none"> All-cause (n = 7543) CVD (n = 2513) Stroke (n = 1053) CHD (n = 452) 	<ul style="list-style-type: none"> All-cause CVD CHD 	<ul style="list-style-type: none"> All-cause CVD Stroke CHD 	<ul style="list-style-type: none"> Vegetables, yes Fruits, yes
Nakamura et al, 2008 ³⁹	29 079	Takayama Study, Japan	FFQ	Mean 7.3	<ul style="list-style-type: none"> CVD (n = 384) 	<ul style="list-style-type: none"> CVD Women, yes Men, no 	None	<ul style="list-style-type: none"> Vegetables, women only Fruits, no
Okuda et al, 2015 ⁴⁰	9112	National Nutrition Survey Japan (1980)	3-day weighed records	Mean 24	<ul style="list-style-type: none"> CVD (n = 823) Stroke (n = 385) CHD (n = 165) 	<ul style="list-style-type: none"> CVD CHD 	<ul style="list-style-type: none"> CVD Stroke 	<ul style="list-style-type: none"> Vegetables, yes Fruits, yes
Oyebo et al, 2014 ⁴¹	65, 226	Health Surveys for England	FFQ and 24-hour diet recall	Median 7.7	<ul style="list-style-type: none"> All-cause (n = 4399) CVD (n = 1554) Cancer (n = 1398) 	<ul style="list-style-type: none"> All-cause CVD Cancer 	<ul style="list-style-type: none"> All-cause CVD Cancer 	<ul style="list-style-type: none"> Vegetables, yes Fruits, yes
Zhang et al, 2011 ⁴²	74 942	Shanghai Women's Health Study, China	FFQ	Mean 10.2	<ul style="list-style-type: none"> All-cause (n = 3442) CVD (n = 1023) Cancer (n = 1485) 	<ul style="list-style-type: none"> All-cause 	<ul style="list-style-type: none"> All-cause CVD 	<ul style="list-style-type: none"> Vegetables, yes Fruits, yes
Zhang et al, 2011 ⁴²	61 500	Shanghai Men's Health Study, China	FFQ	Mean 4.6	<ul style="list-style-type: none"> All-causes (n = 1951) CVD (n = 635) Cancer (n = 853) 	<ul style="list-style-type: none"> All-cause CVD 	<ul style="list-style-type: none"> All-cause CVD 	<ul style="list-style-type: none"> Vegetables, yes Fruits, yes
Sharma et al, 2014 ⁴³	164 617	Multiethnic Cohort Study, United States	FFQ and three 24-hour diet recalls	5-8	<ul style="list-style-type: none"> CHD (n = 1951) 	<ul style="list-style-type: none"> CHD (among men), inconsistent among women 	None	<ul style="list-style-type: none"> Vegetables, yes Fruits, no

Abbreviations: FFQ, Food Frequency Questionnaire; CVD, cardiovascular disease; CHD, coronary heart disease.

^aFruits were associated with unknown causes of mortality.

Gap Between Current Recommendations and Current Intake of Vegetables and Fruits

A final factor to consider in choosing whether to prioritize vegetables over fruits in public health messages is the size of the gap between current consumption and current recommendations. According to the National Cancer Institute, from 2007 to 2010, 87% of the US population did not meet daily recommendations for vegetable intake, whereas 76% did not meet daily recommendations for fruit intake.⁴⁴ In a more recent comparison of vegetable and fruit intake by state conducted by the CDC, 13% of Americans were meeting daily recommendations for fruit intake, whereas only 9% were eating the recommended amount of vegetables.⁴⁵ The extents of both deficits are disturbing, but there is a larger gap between current intake and recommendation for vegetable consumption.

Conclusion

Currently, there appears to be a shift in public health messages around vegetable and fruit consumption. Whereas the normative ordering of this pair of food groups for decades has been “fruits and vegetables,” there are now many examples of health messages referring to “vegetables and fruits.” We have asked the question as to what rhyme or reason might justify one order versus the other, and many possible perspectives were considered.

Linguistically there are general principles of ordering binomials that suggest reasons of sound and syllable to support starting with fruits. But, as health professionals and scientists, we feel that other factors are relevant and should be applied. We dove into the botanical weeds to acknowledge the bounty of anatomical confusion between the two. This would surely incline one to use them together in any health message for the practical purpose of

grounding reason in science. Using the cognitive psychology of word order, a phrase that is less familiar increases the cognitive load needed to process the anomalous word order, and it tends to become more deeply embedded into the memory; this could argue for switching to vegetables first to promote more people to think about both vegetables and fruits and keep them in mind.

Nutritionally, when considering energy density and nutrient density, whereas both food groups beat all packaged processed junk foods to a pulp, there was a trend for vegetables to edge out fruits. Summarizing available observational cohort studies that reported on associations between vegetable or fruit intakes and mortality, the strength of the evidence was slightly more consistent in supporting vegetable intake. Finally, citing current data on American consumption patterns relative to national recommendations, we found a larger gap in vegetable versus fruit intake, which adds greater urgency to emphasizing vegetables first.

Overall, we do find that there are several rationales for referring to this duo as “vegetables and fruits,” rather than “fruits and vegetables.” However, we would not be so bold as to suggest that reversing the trajectory of diet-related chronic diseases depends on getting this order correct. In fact, we strongly believe that meaningful health impacts from dietary changes will require large increases in both vegetable and fruit intake—larger than have been accomplished in recent decades. It is hoped that messaging strategies, such as the USDA transition from the Food Pyramid to MyPlate, will affect behavior change by simply framing half the plate as ideally coming from these two important food groups. Given the disparities between current intakes and recommendations, public health professionals will need to do more to close the gaps for both food groups. But when it comes to vegetables and fruits, we conclude that there is good reason to use “vegetables and fruits” as the word order of choice in public health messaging.

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Informed Consent

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Trial Registration

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References

1. Guenther PM, Casavale KO, Reedy J, et al. Update of the Healthy Eating Index: HEI-2010. *J Acad Nutr Diet*. 2013;113:569-580.
2. US Department of Agriculture, US Department of Health and Human Services. *Dietary Guidelines for Americans*. 7th ed. Washington, DC:Government Printing Office; 2015.
3. Welsh S, Davis C, Shaw A. A brief history of food guides in the United States. *Nutr Today*. 1992;27:6-11.
4. Welsh S, Davis C, Shaw A. Development of the food guide pyramid. *Nutr Today*. 1992;27:12-23.

5. Haven J, Burns A, Britten P, Davis C. Developing the consumer interface for the MyPyramid Food Guidance System. *J Nutr Educ Behav*. 2006;38:S124-S135.
6. US Department of Agriculture. MyPlate/MiPlato. <https://www.cnpp.usda.gov/MyPlate>. Accessed November 11, 2017.
7. Centers for Disease and Control and Prevention. *5 A Day Works!* Atlanta, GA: US Department of Health and Human Services; 2005.
8. Fruit and Veggies More Matters. Home page. <https://www.fruitsandveggiesmorematters.org/>. Accessed November 11, 2017.
9. Harvard T H Chan. The nutrition source: vegetables and fruits. <http://www.hsph.harvard.edu/nutritionsource/what-should-you-eat/vegetables-and-fruits/>. Accessed June 28, 2015.
10. Government of Canada. Vegetables and fruit. <https://www.canada.ca/en/health-canada/services/food-nutrition/canada-food-guide/choosing-foods/vegetables-fruit.html>. Accessed March 22, 2018.
11. Gustafsson M. The syntactic features of binomial expressions in legal English. *Text Interdiscip J Study Discourse*. 1984;4:123-142.
12. Mollin S. Revisiting binomial order in English: ordering constraints and reversibility. *English Lang Linguistics*. 2012;16:81-103.
13. Benor SB, Levy R. The chicken or the egg? A probabilistic analysis of English binomials. *Language*. 2006;82:233-278.
14. Shih SSY. *Towards Optimal Rhythm*. Stanford, CA: Stanford University; 2014.
15. Malkiel Y. Studies in irreversible binomials. *Lingua*. 1959;8:113-160.
16. Anna Siyanova-Chanturia A, Conklin K, van Heuven WJ. Seeing a phrase “time and again” matters: the role of phrasal frequency in the processing of multiword sequences. *J Exp Psychol Learn Mem Cogn*. 2011;37:776-784.
17. Meseguer E, Carreiras M, Clifton C. Overt reanalysis strategies and eye movements during the reading of mild garden path sentences. *Mem Cognit*. 2002;30:551-561.
18. Osterhout L, Holcomb PJ. Event-related brain potentials elicited by syntactic anomaly. *J Mem Lang*. 1992;31:785-806.
19. Smith NJ, Levy R. The effect of word predictability on reading time is logarithmic. *Cognition*. 2013;128:302-319.
20. Thompson FE, Willis GB, Thompson OM, Yaroch AL. The meaning of “fruits” and “vegetables.” *Public Health Nutr*. 2011;14:1222-1228.
21. Nienhuis J, Slocum MK, DeVos DA, Muren R. Genetic similarity among *Brassica oleracea* L. genotypes as measured by restriction fragment length polymorphisms. *J Am Soc Hortic Sci*. 1993;118:298-303.
22. Kantor LS. *A Dietary Assessment of the US Food Supply: Comparing Per Capita Food Consumption With Food Guide Pyramid Serving Recommendations*. Vol 772. Beltsville, MD: US Department of Agriculture, Economic Research Service; 1998.
23. *Nix v Hedden*, 149 US 304, 137 (1893).
24. US Department of Agriculture. Nutrient Data Laboratory, release 27. <https://www.ars.usda.gov/northeast-area/beltsville-md-bhnrc/beltsville-human-nutrition-research-center/nutrient-data-laboratory/docs/sr27-home-page/>. Accessed March 22, 2018.
25. US Food and Drug Administration. Nutritional Labeling and Education Act (NLEA) Requirements (8/94-2/95). <http://www.fda.gov/ICECI/Inspections/InspectionGuides/ucm074948.htm>. Accessed May 10, 2016.
26. Kimmons J, Gillespie C, Seymour J, Serdula M, Blanck HM. Fruit and vegetable intake among adolescents and adults in the United States: percentage meeting individualized recommendations. *Medscape J Med*. 2009;11:26.
27. Furman J. *Nutritarian Handbook and ANDI Food Scoring Guide*. Flemington, NJ: Gift of Health Press; 2012.
28. Katz DL, Njike VY, Kennedy D, Faridi Z, Treu J, Rhee LQ. *Overall Nutrition Quality Index: Reference Manual*. Derby, CT: Yale University School of Medicine; 2007.
29. Cao G, Prior RL. Measurement of oxygen radical absorbance capacity in biological samples. *Methods Enzymol*. 1999;299:50-62.
30. Haytowitz DB, Bhagwat S. *USDA Database for the Oxygen Radical Absorbance Capacity (ORAC) of Selected Foods, Release 2*. Beltsville, MD: US Department of Agriculture; 2010.
31. Bellavia A, Larsson SC, Bottai M, Wolk A, Orsini N. Fruit and vegetable consumption and all-cause mortality: a dose-response analysis. *Am J Clin Nutr*. 2013;98:454-459.
32. Buil-Cosiales P, Zazpe I, Toledo E, et al. Fiber intake and all-cause mortality in the Prevencion con Dieta Mediterranea (PREDIMED) study. *Am J Clin Nutr*. 2014;100:1498-1507.
33. Cox BD, Whichelow MJ, Prevost AT. Seasonal consumption of salad vegetables and fresh fruit in relation to the development of cardiovascular disease and cancer. *Public Health Nutr*. 2000;3:19-29.
34. Choi Y, Lee JE, Bae JM, et al. Vegetable intake, but not fruit intake, is associated with a reduction in the risk of cancer incidence and mortality in middle-aged Korean men. *J Nutr*. 2015;145:1249-1255.
35. Hertog MG, Bueno-de-Mesquita HB, Fehily AM, Sweetnam PM, Elwood PC, Kromhout D. Fruit and vegetable consumption and cancer mortality in the Caerphilly Study. *Cancer Epidemiol Biomarkers Prev*. 1996;5:673-677.
36. Hung HC, Joshupura KJ, Jiang R, et al. Fruit and vegetable intake and risk of major chronic disease. *J Natl Cancer Inst*. 2004;96:1577-1584.
37. Leenders M, Boshuizen HC, Ferrari P, et al. Fruit and vegetable intake and cause-specific mortality in the EPIC study. *Eur J Epidemiol*. 2014;29:639-652.
38. Nagura J, Iso H, Watanabe Y, et al. Fruit, vegetable and bean intake and mortality from cardiovascular disease among Japanese men and women: the JACC Study. *Br J Nutr*. 2009;102:285-292.
39. Nakamura K, Nagata C, Oba S, Takatsuka N, Shimizu H. Fruit and vegetable intake and mortality from cardiovascular disease are inversely associated in Japanese women but not in men. *J Nutr*. 2008;138:1129-1134.
40. Okuda N, Miura K, Okayama A, et al. Fruit and vegetable intake and mortality from cardiovascular disease in Japan: a 24-year follow-up of the NIPPON DATA80 Study. *Eur J Clin Nutr*. 2015;69:482-488.
41. Oyebo O, Gordon-Dseagu V, Walker A, Mindell JS. Fruit and vegetable consumption and all-cause, cancer and CVD mortality: analysis of Health Survey for England data. *J Epidemiol Community Health*. 2014;68:856-862.
42. Zhang X, Shu XO, Xiang YB, et al. Cruciferous vegetable consumption is associated with a reduced risk of total and cardiovascular disease mortality. *Am J Clin Nutr*. 2011;94:240-246.
43. Sharma S, Vik S, Kolonel LN. Fruit and vegetable consumption, ethnicity and risk of fatal ischemic heart disease. *J Nutr Health Aging*. 2014;18:573-578.
44. National Cancer Institute. Epidemiology and Genomics Research Program. Usual dietary intakes: food intakes, US population, 2007-2010. <http://epi.grants.cancer.gov/diet/usualintakes/pop/2007-10/>. Accessed June 1, 2016.
45. Moore LV, Thompson FE. Adults meeting fruit and vegetable intake recommendations—United States, 2013. *MMWR Morb Mortal Wkly Rep*. 2015;64:709-713.