

From the pages of [Jim Prevor's Perishable Pundit](#)

We've been honored to speak and moderate many panels over the years at the Culinary Institute of America. We've always felt that influencing and educating chefs and future chefs is important to encourage produce usage in restaurants and institutions. This is why we have invested to create a [special program](#) to bring culinary students to the [New York Produce Show and Conference](#) to get them used to working with fruits and vegetables and to let these students see the variety the industry offers.

It was through presenting and moderating at these CIA events, such as [Menus of Change](#) and the [Worlds of Healthy Flavors](#), that we first met [Professor Walter Willett](#), of the [Harvard T.H. Chan School of Public Health](#), almost certainly the world's most prominent and respected expert on nutrition. When we read he had participated in a "big picture" study, involving more than 100,000 people, and over 33,000 deaths, all focused on fruit and vegetable intake and the impact of such impact on mortality, we knew we had to dig in.

It is not an easy read, and we owe great thanks to our own Investigator and Special Projects Editor, Mira Slott, for doing the yeoman's task of finding, analyzing and presenting many important links for amplification and further study.

Assessing and understanding all this is difficult but very important. The latest [Produce for Better Health Research](#) points to a continuous decline in produce consumption per capita. Although individual products still increase and individual companies are doing well, it will be difficult to sustain a growing industry if we can't turn around consumption.

Over the years, we have done many articles about different efforts to boost consumption. Some of these efforts have succeeded, but most have failed. Almost all have had only the slightest of science to justify their efforts or quantify their impact. We asked Mira Slott to help us understand this large and important study:



Walter Willett, M.D., Dr. P.H.

Professor of Epidemiology and Nutrition

Harvard T.H. Chan School of Public Health

Professor of Medicine at

Harvard Medical School

Q: When we met in 2019 at [CIA's Menu of Change Summit](#) (before the pandemic turned such events virtual), you provided many smart, pithy comments for the [PRODUCE BUSINESS](#) cover story, that I was writing, on the [Plant Forward Movement](#), including a memorable quote:

"I see the Impossible Burger as a nicotine patch for people trying to quit meat. We need to pull out all the stops and use our imagination...We're off the path. We can't sell a deprivation diet. It takes a reorientation, not to just have vegetarian options but creative delicious ones."

Your comments are telling. As we discuss the challenges to scientifically link diet and F&V intake to lower mortality rates, we recognize this is only one aspect in the produce industry's efforts to increase produce consumption. So let us dive into your recently published research study:

[Fruit and Vegetable Intake and Mortality: Results From 2 Prospective Cohort Studies of US Men and Women and a Meta-Analysis of 26 Cohort Studies](#)

As a co-author, [and a leader in seminal aspects](#) of the [long-term, extensive research and data analysis](#) involved — in concert with your broad body of work and expertise — you proffer unique insights and perspectives.

These landmark cohort studies have proven impactful in influencing government health and nutritional policies, shifting [Dietary Guidelines \(2020-2025\)](#), and funding allocations for various initiatives. They have generated a plethora of related research, corroborating and in some instances countering certain results, and thousands of articles on the benefits of fruit and vegetable intake linked to reducing risks of many diseases.

We have reported extensively on various issues surrounding your research in [PRODUCE BUSINESS](#) and our online publication, [The Perishable Pundit](#), as well as at our annual [New York Produce Show and Conference](#), which has stimulated dynamic, controversial discussions over the years. *Editor's note: You can read a few pieces here:*

[An Observational Study Is Not An Experiment: Cautions In Research Interpretation](#)

[Advocating Produce As Part of Public Health Initiatives](#)

[You Really Aren't What You Eat: Are Our Dietary Guidelines Based On 50 Years Of Flawed Science? And What Would It Mean For Efforts To Boost Produce Consumption If This Is So?](#)

[Food "To Die For" May Do Just That... Seminal Study Encouraging The Eating Of Bitter Vegetables For Health To Be Unveiled At New York Produce Show And Conference](#)

After examining the study, numerous questions have arisen, which are of great interest to our produce industry readers. Since our time is limited, I focused on some key points related to components of the study, many of which are complex. Let's start and see what we can accomplish. Did you find results of the study unexpected in any way? What was the most surprising or enlightening information you gleaned?

A: I wasn't really too surprised by the findings because it's pretty much what we saw [when we looked earlier with cardiovascular disease as the outcome](#), and, of course, cardiovascular disease (CVD) is a major cause of death. So, the results in actual total mortality were pretty much what we've seen with CVD. Basically, there's benefits with eating more fruits and vegetables. But it's not a straight line. It's not necessarily reducing a risk by just eating larger and larger amounts. We see a plateau around five a day.

Q: Do you find it strange that all the benefits for reducing mortality rates and risk of cancer, and CVD occur between 3 to 5 servings per day of F&V, and any additional servings have no apparent value in terms of mortality? (In the conclusions: "Higher intakes of fruit and vegetables were associated with lower mortality; the risk reduction plateaued at 5 servings of fruit and vegetables per day. The thresholds of risk reduction in mortality were two servings daily for fruit intake and three servings daily for vegetable intake.")

A: It's not surprising at all. Most biological relationships are not linear. For example, for essential nutrients, if we're lower or deficient, we get more and our health improves, but then we get to a point where we have enough, and adding more is not providing more benefit. And that can be because we've matched our absorption or we've saturated an enzyme, where the nutrient is providing its benefit and once you've saturated the enzyme anymore it doesn't provide more benefit. And for ones that you have too much, then you start to get toxicity, but we didn't see that for fruits and vegetables in the range that we were looking at in general. However, for some like starchy vegetables and potatoes, you actually have adverse effects because of all the starch.

[Editor's Note: This seems to concur with a [prospective cohort study looking at F&V intake, CDV and deaths in 18 countries published in 2017](#), where “benefits appear to be maximum for both non-cardiovascular and total mortality at three to four servings per day (equivalent to 375-500g/day).” [Editor's note: [The Cox frailty models](#) with random effects were used to assess associations between fruit, vegetable and legume consumption with risk of CDV and mortality. The Cox proportional hazards model, a multivariate statistical analysis, was used in the Fruit and Vegetable Intake and Mortality study as well, which is discussed later in the interview].

Yet, a 2004 filtered study, based on data from the Nurse's Health Study and Professionals Follow-Up study, published in the Journal of the National Cancer Institute: [Fruit and Vegetable Intake and Risk of Major Chronic Disease](#), reports:

“The higher the average daily intake of fruits and vegetables, the lower the chances of developing cardiovascular disease. Compared with those in the lowest category of fruit and vegetable intake (less than 1.5 servings a day), those who averaged 8 or more servings a day were 30% less likely to have had a heart attack or stroke.”

[Revised Dietary Guidelines in 2007](#) ranged from 4-13 servings of F&V. In response, the [Centers for Disease Control](#) and the [Produce for Better Health Foundation](#) replaced the [5-A-Day](#) campaign, a mainstay since the 90's, with [Fruit and Veggies More Matters](#) campaign, suggesting more than 5 servings a day was better.

In a reimagined effort to reverse stagnant produce consumption, PBH launched [Have a Plant](#), leveraging behavioral science and consumers emotional connections to health and wellness, “rather than a prescriptive recommendation to eat a certain amount of fruits and vegetables each day.” At the same time, it includes all forms; fresh, frozen, canned, dried and 100 percent fruit juice products.]

Q: [You refuted](#) a New York Times 2015 piece, titled [The Government's Bad Diet Advice](#), related to longstanding Dietary Guidelines being challenged. The NYT pointed out: “Much of the epidemiological data underpinning the government's dietary advice comes from studies run by Harvard's School of Public Health. In 2011, directors of the National Institute of Statistical Sciences [analyzed many of Harvard's most important findings](#) and found that they could not be reproduced in clinical trials.”

First, you make the point that the [Dietary Guidelines](#), published every five years, are a reflection of the most up-to-date research. You argue:

“One claim of the New York Times article was that we can only rely on clinical trials for information on diet and health. In theory, we might like to have clinical trials to answer all such questions, but for issues that involve long term effects of diet that occur over many years and decades — for example, effects on heart disease and cancer — clinical trials have mainly been a failure because keeping people on specific diets over many years is difficult.

So, the theoretically perfect study will often just not be possible; therefore, we have to use a combination of kinds of evidence. For most questions, the best evidence will come from a combination of large cohort studies tracking the dietary habits and disease occurrence of participants over many years and small, short term studies in which a small number of participants are fed different diets and intermediate variables like blood pressure and cholesterol fractions are measured.”

In the [NHS questionnaires](#), there is [a lot of info about different fruits and vegetables \(F&V\)](#) and how they're prepared. It appears that this detailed info is not used in the conclusions of the Fruit and Vegetable Intake and Mortality impacts, other than excluding the starchy vegetables (corn, potatoes) and fruit juices. Could you comment on this?

A: Well, some of the questions how it was prepared relates to the amount. For instance, if you have spinach in a salad, you're going to consume less of it than if you have spinach as a vegetable on your plate. You know, when you cook a big bunch of spinach, you get about one tenth or less the volume, so you end up eating more spinach when it's cooked than when it's part of a salad. So, a lot of our questions about spinach related to different amounts, depending on how you had it.

But we have looked at other times whether just cooking vegetables makes a difference, and we haven't seen that it makes much difference. It can if you really look at specific vegetables. For example, for tomatoes, if you cook them, you should get better absorption of some of the phytochemicals, the carotenoids... It's not all a one-way street. If you overcook some vegetables, depending on how long you cook them, you can destroy some [antioxidants](#) in vegetables. So, you could go into more detail to come to certain conclusions, but we don't have that kind of detail.

Q: Many studies look to assess effects of individual fruits and vegetables, including filtered sets from the NHS data. For diabetes, [a study](#) of over 66,000 women in the Nurses' Health Study, 85,000 women from the Nurses' Health Study II, and 36,000 men from the Health Professionals Follow-Up Study, found that greater consumption of whole fruits — especially blueberries, grapes and apples — was associated with lower risk of Type-2 diabetes. Conversely, a greater consumption of fruit juice was associated with a higher risk of Type-2

diabetes.

Additionally, [a study](#) of over 70,000 female nurses aged 38-63 who were free of CVD, cancer and diabetes, showed that consumption of green leafy vegetables and fruit was associated with a lower risk of diabetes. At the same time, “While not conclusive, [it acknowledges], research also indicated that consumption of fruit juices may be associated with an increased risk among women.”

Did you consider how the kinds and total variety of fruits and vegetables a participant ate could impact mortality, whether it was iceberg lettuce or kale, bananas or blueberries, for instance, in terms of the nutrients, antioxidants, and the effects based on the disease, and accounting for people’s varying medical conditions, weight issues, etc.?

A: Not in this analysis. When we calculate nutrients, we definitely do take that into account, and it’s an important point, looking in more detail. When looking at total mortality, people think it’s simple, but that’s the most complicated thing to look at, because people die of many, many different causes, and the risk factors are different, and the timing of the risk factors are different as well.

So, in some ways looking at total mortality is almost always giving us a superficial picture. There are advantages when you look at the big picture, but then the disadvantage is that you lose a lot of the nuances.

Q: So, you’ve already accepted that with this study. The multivariate statistical analysis was performed using the Cox proportional hazards model. My understanding is that this model “provides (an) effect size for each factor.” Since fruit and vegetable consumption is associated with other factors, the statistical analysis is “regressing out” (adjusting for other variables):

- lower prevalence of smoking
- lower animal fat consumption
- higher level of physical activity
- higher fiber consumption

Which factors are significant with respect to mortality, cancer, CVD, and respiratory disease? Which factors are more important than F&V intake with respect to mortality, cancer, CVD, and respiratory disease?

A: These are complex questions and require a long answer. It would depend on which type

of disease... is it cancer mortality, CVD mortality... It's different for all of them.

But very broadly, smoking is usually the strongest risk factor. And what we're doing is controlling for the risk factor, putting that into the Cox proportional hazards model. We know that people who smoke more eat less fruits and vegetables. So, we adjust for this in the analysis.

Q: That's the thing that threw me off based on the graphs and the conclusions drawn.

In the graph for F&V intake on total mortality [Editor's note: you can find the graph in the [Fruit and Vegetable Intake and Mortality study](#) on page 8], for cancer mortality, you see a decrease in mortality of about 10 percent with five servings. For cardiovascular disease mortality, you see about 13-14 percent with five servings, but with respiratory disease mortality, you see about 35 percent with five servings, a dramatic decrease in mortality, while with neuro-degenerative disease mortality, you see no real effect regardless of the amount of F&V intake.

The most significant beneficial effect, and overwhelmingly so, is for respiratory disease, but this is what you would expect from smoking, and there was an inverse correlation between smoking and F&V intake.

Do you think that the application of the regression of smoking in the analysis overcorrected for this relationship? Was (or could there be) an analysis conducted on a subset of the participants where the impact of F&V intake was examined for only non-smokers and for only smokers? Would such an analysis confirm the impact of F&V intake on respiratory mortality?

A: You commented that for respiratory disease the relation seemed to be the strongest benefit of fruits and vegetables. And we know that smoking is strongly related to respiratory disease. But smoking is also strongly related CVD and cancer as well; it just cuts across the board.

Q: So, it would be important to regress out the influence of smoking when assessing the benefits of F&V intake on cancer and CVD as well...

A: We are quite aware smoking could be a confounding factor, so we adjust for that in a lot of detail. It's not just whether they smoke, but whether it was in the past, whether it was current, and if current, how many cigarettes a day. So, we've been quite careful about assessing the smoking, and it's kind of implied you could look at people who eat fruits and

vegetables and people who never smoked, and you run into low numbers there because people who never smoked never had heart disease, so it's hard to look at that group with a lot of precision.

Q: What did you think of my question of filtering a subset to just examine fruit and vegetable intake for only non-smokers or just smokers, to pull that out separately?

A: That's a very good question. We usually do that filtering out, and then we end up with respiratory disease as the cause of death. It definitely would be a good thing to do. But I think quite likely that all of the antioxidants in fruits and vegetables are partly counteracting some of the damage that smoking is causing.

CONFIRMING THE DIET/HEALTH LINK WITH BODY CHEMISTRY IMPACTS

Q: The conclusions in this Fruit and Vegetable Intake and Mortality study appear to jump directly from diet differences to the health benefit/disbenefit without referencing a previously confirmed body-to-health-benefit relationship. For instance, you participated in the [first meta-analysis of randomized controlled trials that showed substituting healthy plant proteins for red meats reduced CVD](#). The study, [published in Circulation in 2019](#), included data from 36 randomized controlled trials involving 1,803 participants.

The researchers compared people who ate diets with red meat to those people who ate more of other types of foods (i.e., chicken, fish, carbohydrates, or plant proteins such as legumes, soy, or nuts), looking at blood concentrations of [cholesterol](#), triglycerides, lipoproteins, and blood pressure — all risk factors for CVD.

The study found that when diets with red meat were compared with all other types of diets combined, there were no significant differences in total cholesterol, lipoproteins, or blood pressure, although diets higher in red meat did lead to higher triglyceride concentrations than the comparison diets.

However, researchers found that diets higher in high-quality plant protein sources such as legumes, soy, and nuts resulted in lower levels of both total and LDL (“bad”) cholesterol compared to diets with red meat.

Were the blood and urine samples that were available from the participants used to draw any conclusions about how F&V intake resulted in changes in their body that were consistent with findings in the Fruit and Vegetable Intake and Mortality report? It seems

this was a real advantage you had in terms of the data available to analyze.

A: [In the Fruit and Vegetable Intake and Mortality study], we didn't have enough of this data to do that kind of analysis. We have the blood samples, about 50,000, but not on all of the participants. So, we couldn't use all of the data to look at that, and we have seen that people who have more fruits and vegetables have higher levels of blood carotenoids. You would expect that, higher folate levels, and higher intake of some phytochemicals as well as high antioxidants.

So, it's very possible, but it's hard to directly prove that fruits and vegetables are responsible factors. But in testing analysis, it does appear there can be an influence against some of the free radicals caused by smoking.

META-ANALYSIS MULTIPLICITIES

Q: I also wanted to ask you about the Meta-Analysis of the 26 prospective cohort studies. How does the multiplicity of studies compare to the Nurses and Health Professional studies, with respect to their methodologies, the data received, participants, and length of time? Were there a lot of variants in that, and how did it work?

A: Right. That's a good question. I'm an epidemiologist sometimes, and these are the kinds of questions people ask, whether the studies are really comparable. And these studies are not exactly comparable. Maybe I'm a little biased, but I think our studies (The Nurses and Health Professional studies) are the best and most detailed for a couple of reasons.

One is that many of the other studies only had one dietary assessment. And we do dietary assessments every four years. Number Two, which could be viewed as a negative but I think mostly positive, that everyone in our study had a pretty similar education and economic status because we selected health professionals, and by doing that we limit confounding factors.

Q: So, it has its pros and cons, because on one hand it is not as diverse a population, but then it is less complicated for regressing out the other risk factors. In the list of characteristics, many of them remain relatively constant when split into quintiles of fruit and vegetable intake.

[Editor's note: [\[See page 5, Table 1. Age-Adjusted Characteristics of Men and Women Across Levels of Fruit and Vegetable Intakes.\]](#)

Some standouts, the participants who ate more servings of fruits and vegetables were found

to have exercised significantly more. The participants who ate few fruits and vegetables were found to have included a dramatically higher number of people who smoked.

Another challenge that arises with collecting data is that consumers don't always provide reliable information on their produce consumption, whether intentionally or not. The study points out that health professionals may be more knowledgeable and accurate in the types of data you're asking them to provide, and in their commitment to participate in the study long term. Yet, accuracy of the data still could be an issue considering that people are not apparently keeping a daily record of their F&V intake...

Were there any natural experiments, where food type and quantity were controlled, for instance, because of cultural eating habits, like a traditional Japanese diet? I remember a story about a [Greek island](#) where everyone lived longer because of their lifestyles and what they ate...

A: In general, with nutrition you don't place that much weight on those types of studies because there are so many confounding factors that you can't control very well.

It's sometimes a lead, or can get started on a hypothesis in general and then try to go into more detail studies like these. In this particular example of Japan, fruits and vegetables are consumed pretty broadly across lots of different parts of the world, so the contrast in intake of a natural experiment won't be that strong.

CAUSALITY VS ASSOCIATION

Q: Can you discuss further the challenges of distinguishing causality from association in nutritional studies? We find many anecdotal and observational studies in the produce industry — which are often used to make important governmental health and nutritional policies and guidelines. What are your thoughts?

A: It's always a good question. In theory, you'd like to do a randomized trial, where you randomly assign some people to high vegetable intake and some to low vegetable intake, and then follow them for 30 to 40 years. But such trials will probably never be done. People wouldn't volunteer to do it, and they wouldn't stay on the diet if you assign them to it. So, we'll probably never be able to do a theoretically ideal study.

So, we have to use a combination of different kinds of evidence. And one type of study rarely proves, or gives us a high certainty of causality. But, it's usually through a combination of studies, like our long-term epidemiological studies, where we didn't randomize people. But

if the results are consistent with other short-term studies you might do in a laboratory, showing there are beneficial effects in a test tube or in animals — which there have been for fruits and vegetables — then when you have that combination of evidence, it can bring us to a high level of certainty that these are likely to be beneficial cause-and-effect relationships.

Or, also, if there are intermediate endpoints in human studies, where you can do short randomized trials... For example, we do show that higher potassium intake you can get from fruits and vegetables reduces blood pressure, and high blood pressure is a very high-risk factor for cardiovascular disease. That, I think, is part of the reason we see benefits, especially for cardiovascular disease. It makes it very likely or at least partially causal.

Q: And that study, you've also done?

A: Yes. [We did that a number of years ago.](#) We actually randomized people to a double-blind potassium and placebo pills. And the people who had potassium pills had lower blood pressure. And this has been shown in other studies also.

[Editor's Note: This potassium study shows a group of women having blood pressure in a normal range and whose diet was low in fruits and vegetables, obtained a small, but statistically significant, lowering of blood pressure by taking a predetermined level of potassium supplement, but saw no statistically significant effect of lowering blood pressure by taking a predetermined level of calcium or magnesium supplements.]

IF MONEY WASN'T AN ISSUE

Q: What further research would you like to do based on the findings in the Fruit and Vegetable Intake and Mortality study? If money wasn't an issue, how would you design a study to examine diet on health? How long would it take?

A: I'm actually looking at creating a nutrition bar or something like that, which would contain a number of fruits and vegetables that we could use in a randomized trial to make a clear distinction from what people are eating, just for research purposes, not necessarily would we want people to eat fruits and vegetables that way, but to be able to look at some shorter-term outcomes like cognitive function.

Also, we do have data from about 30 prospective studies in our computer on mortality. If you gave me half a million dollars, we could do some detailed analyses, combining the data from about 30 different studies that we could use. And that could be another thing we could do.

Q: To clarify, why a nutrition bar, versus particular fresh fruits and vegetables?

A: It might turn out to be a packet of dried fruit and vegetables we could give to people in an experimental study. It's so hard to tell people to go eat five servings of fruits and vegetables a day and stay on that for a couple of years. So, we were trying to find a way to make it easier for people.

Q: Well, that's "food for thought" for the produce industry. Maybe someone could come up with a product for you.

A: That would be fantastic.

Q: Your dilemma in getting people to eat five servings of fruits and vegetables a day over extended timeframes — your research is something produce industry executives can sympathize with!

I see we've gone over our allotted interview time, and while there's so much more to unravel, I know you've got a packed schedule. Thank you for your graciousness in fielding my quick-fire range of often vexing questions and shedding light on these complex issues.

A: You've covered a lot, so you were really good!

In the end, the conclusion of this study is both exhilarating for the produce industry and stark for some of our institutions — with many questions still to be answered. The summary conclusion of the study states this:

Conclusions:

Higher intakes of fruit and vegetables were associated with lower mortality; the risk reduction plateaued at ≈5 servings of fruit and vegetables per day. These findings support current dietary recommendations to increase intake of fruits and vegetables, but not fruit juices and potatoes.

This is a study that reflects how people actually consume fruits and vegetables. It is not a study of the items themselves. Potatoes are excluded from part of the research and included in other parts. So the critique of potatoes likely reflects the high consumption of French Fries, all fried in oil, of course, and of baked potatoes or mashed potatoes consumed with butter, bacon, cheese, etc. It also leaves open the way people actually consume food. For

years I used to grab a baked potato at Wendy's — there was the potato and cheese and broccoli. I never would have had that broccoli at my fast-food lunch if that overall option hadn't been available.

It does pose a challenge for the produce industry since if we are going to want to present all produce as healthy, we may need a big emphasis on how we can encourage people to eat potatoes in a healthy fashion, such as baked potatoes with yogurt or making sure to eat the high fiber skin of the potato, or ways of integrating broccoli or other vegetables in the offer, etc.

The study also raises the question of the inclusion of 100% juice products and whether the mandate of including 100% juice in the Produce for Better Health Foundation platform and its [Have a Plant](#) program actually is a good idea.

This type of study is fantastic, and the industry should look at Dr. Willett's request for about half a million dollars in funding to bring this to the next stage. He also is looking for a way to create a nutrition bar or, perhaps, give people a daily packet of produce, again to do better research.

These are worthy projects, and we hope industry members will step up and help this research advance. Feel free to let us know [here](#) if you want us to help facilitate this process.

Cause and effect remain difficult to winnow out. People with high produce consumption may also exercise more, go to the doctor regularly, make a point of de-stressing, perhaps have more fulfilling relationships — it is so difficult to pull out one variable as the cause of their health or longevity.

Yet the big dilemma is actually quantification. It is hard to "sell" changing diets without clear and specific benefits. It is not very persuasive to say that if people do something, they will live longer (on average).

In other words, say that one hates running, but imagine we could prove that if people would devote an hour a day to running, seven days a week, starting when they were 16 years old until they die, then, on average they would live an extra two weeks. We doubt many people will be persuaded to take up running. If you could show that, on average, they would live 30 years longer, all in good health — running shoes will start flying off the shelves.

People mostly eat what they want to, within their budgets. If we hope to get people to change their behavior, we need to find a way to quantify the health benefits of increasing

fruit and vegetable consumption, not just proclaim that there are benefits,

We thank Dr. Willett for sharing with us an understanding of this research and what it could mean in prompting people to change consumption patterns to eat more fruits and vegetables.