Specific Foods and Cancer Mortality

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Many cancers are associated with poor diet, lack of physical activity, and excess weight. Improving any of these three lifestyle factors would likely reduce cancer deaths.

: dietary modification cardiorespiratory fitness physical activity

1. Red Meat

A frequently cited association between diet and cancer mortality is red meat. Pan et al. aggregated data from the Health Professionals Follow-up Study (HPFS) and the Nurses' Health Study (NHS) to show a 19% increased risk of cancer mortality in those that ate roughly three servings (the highest quintile) of total red meat (which included both processed and unprocessed meat) vs. those that ate about half a serving (the lowest quintile) (HR = 1.19 [95% CI, 1.11–1.28]) [1]. The study also mentions a 10% increased risk in cancer death per serving of total red meat (HR = 1.10 [1.07–1.13]). For context, the standard serving size is classified differently based on the type of meat: one serving of unprocessed red meat is 85 g (a 3-ounce steak), while one serving of processed meat is classified as 13 g of bacon (one large/two small strips), 45 g of hot dogs (one frank), or 28 g of sausage, salami, bologna, and other processed red meats (one large deli slice) [1].

Other large epidemiological datasets within the United States have shown similar results. Sinha et al. examined over half a million people in the United States and demonstrated a roughly 20% increased risk of cancer mortality in the highest quintile of total red meat intake vs. the lowest in both men and women (HR = 1.22 [1.16–1.29] and HR = 1.20 [1.12–1.30], respectively) [2]. Combing both the Pan and Sinha studies, a meta-analysis by Wang et al. showed a 12% increased risk of cancer mortality per serving of total red meat (HR = 1.12 [1.10–1.14]) [3] (**Table 1**). It is worth mentioning that calorie intake was lower and physical activity was higher in the groups who ate the least red meat in the Pan and Sinha studies, both of which used multivariate analysis to correct for those factors. However, such group differences do suggest that additional differences between the quintiles might exist and for which complete accounting might be difficult.

Table 1. Aggregation of the many adjusted hazard ratios from the meta-analyses detailing the association of a specific lifestyle factor with cancer mortality. Examples are given to suggest the changes required to potentially derive the associated cancer mortality benefit.

Lifestyle Factor Associated with Cancer Mortality	Hazard Ratio (95% CI)	Hazard Ratio Relative to ________	Examples of Lifestyle Intervention to Derive Associated Cancer Mortality Benefit
Unprocessed Red Meat [3]	HR = 1.03 (0.95–1.13)	per daily serving	Reduction by: 1 large strip of bacon (~13 g/slice); 1 hot dog (45 g/frank); 2 slices of salami, bologna (~14 g/slice), per day.
Processed Red Meat [3]	HR = 1.08 (1.06–1.11) *	per daily serving	One fewer 3-ounce steak (~85 g) per day.
Total Red Meat [3]	HR = 1.12 (1.10–1.14)	per daily serving	One fewer of any combination of the examples given in the processed and unprocessed red meats sections per day.
Fiber [4]	HR = 0.86 (0.79–0.93)	High vs. low (~25+ g/day vs. ~10 g/day [5])	A daily meal plan of: a cup of oatmeal (5 g fiber) topped with a half cup of raspberries (4 g fiber) for breakfast plus an orange (3 g fiber) and a large handful (20 nuts) of almonds (3 g fiber) for lunch plus one cup of chopped broccoli (5 g fiber) over a cup of quinoa (5 g fiber) for dinner.
Fiber [4]	HR = 0.94 (0.91–0.97)	per 10 g/day	An additional: 1 cup of canned baked beans; 2½ cups of Brussel sprouts; 3 large bananas; 5 slices of whole wheat bread, per day.
Nuts [6]	HR = 0.86 (0.75–0.98)	High vs. low (Roughly > 5 servings per week vs. roughly < 1 serving per month/never [7][8])	An additional: 115 almonds, 90 cashews, 70 walnuts, 95 pecans, 245 pistachios per week.
Whole Grains [9]	HR = 0.82 (0.69–0.96)	per 50 g/day	An additional **: ⅔ cups of old-fashioned oats †; ¾ cup cooked quinoa (¼ uncooked) †; 3 slices of 100% whole wheat bread ‡; 3 cups of Cheerios ‡, per day.
Vegetables [10]	HR = 0.99 (0.97–1.01)	per daily serving	N/A
Fruit [10]	HR = 0.99 (0.97–1.00)	per daily serving	N/A
Fish [11]	HR = 0.99	High vs. low (roughly 3×/week vs.	N/A

Lifestyle Factor Associated with Cancer Mortality	Hazard Ratio (95% CI)	Hazard Ratio Relative to ________	Examples of Lifestyle Intervention to Derive Associated Cancer Mortality Benefit
	(0.94–1.05)	<1×/month [12])	
Poultry [11]	HR = 0.96 (0.93–1.00)	High vs. low (roughly 2×/week vs. <1×/month [12])	N/A
Total Dairy [13]	HR = 0.99 (0.92–1.07)	High vs. low (roughly ≥2×/day vs. <0.5/day)	N/A
Legumes [14]	HR = 0.85 (0.72–1.01)	High vs. low (roughly 27.8 g/day vs. 0 g/day [15])	N/A
Eggs [16]	HR = 1.20 (1.04–1.39)	High vs. low (roughly half an egg/day vs. ≤3 egg/month [17])	Decreasing egg consumption from 12 medium-sized eggs, or 4 omelets, per month to about 3 medium-sized eggs, or one omelet, per month.
SSBs ◊ [18]	HR = 1.06 (1.01–1.12)	High vs. low (≥2 SSBs/day vs. <1 SSB/month [19])	Decreasing consumption of two 12-ounce cans of soda (~80 g of sugar) per day to less than one 12-ounce can per month.
CRF [20]	HR = 0.55 (0.47–0.65)	High vs. low (~13 METs vs. ~8.5 METs for men; ~12 METs vs. ~7 METs for women [21][22])	Training a man who can sustain 6–7 min ® of ~12 min per mile pace (5 mph) to sustain 6–7 min of ~6-min per mile (10 mph); Training a woman who can sustain 6–7 min of ~13:20 min per mile pace (4.5 mph) to sustain 6–7 min of ~7:15-min per mile (8.3 mph).
CRF [20]	HR = 0.80 (0.67–0.97)	Moderate vs. low (~11 METs vs. ~8.5 METs for men; ~9 METs vs. ~7 METs for women [21][22])	Training a man who can sustain 6–7 min of ~12 min per mile pace (5 mph) to sustain 6–7 min of ~10-min per mile (6 mph); Training a woman who can sustain 6–7 min of ~13:20 min per mile pace (4.5 mph) to sustain 6–7 min of ~11:30-min per mile (5.2 mph).
Hand grip [23]	HR = 1.27 (1.01–1.59)	Lowest third vs. highest third	Grip strength of roughly < 20 kg vs. >30 kg; this is the force exerted on a hand dynamometer.
Hand grip [23]	HR = 1.12	Lowest third vs. middle third	Grip strength of roughly < 20 kg vs. roughly 20–30 kg; this is the force exerted on a hand

Lifestyle Factor Associated with Cancer Mortality	Hazard Ratio (95% CI)	Hazard Ratio Relative to ________	Examples of Lifestyle Intervention to Derive Associated Cancer Mortality Benefit [3][27][28]
	(1.03–1.23)		dynamometer.
Physical Activity € [3][24]	HR = 0.83 (0.79–0.87)	High vs. low (very roughly ≥ 25 MET-hours per week vs. little to no MET-hours per week) ¥	~1 h per day (7 h over a week) of walking at a moderate pace (3 mph); running at 10 min-per-mile pace for 30 min 5x/week; playing 2 rounds of golf per week (using a golf cart); 4 h per week of resistance training (lifting weights) plus 2 h per week of gardening plus 1 h of playing tennis. [3][29]
Physical Activity € [24]	HR = 0.88 (0.82–0.95)	5 MET-hours per week vs. little to no MET-hours per week ¥	~1 h of a leisurely bike ride per week; gardening about two hours per week; ~2 h per week of casual walking.
Obesity [25]	HR = 1.17 (1.12–1.23)	Obese (BMI ≥ 30) vs. non-obese (BMI < 30) [29]	A 5′ 9” man, weighing 220 pounds (BMI 32.5), who loses 25 pounds (BMI 28.8). A 5′ 4” female, weighing 190 pounds (BMI 32.6), who loses 20 pounds (BMI 29.2).

servings per day to less than one, over a 25-year period, one person would be spared death from cancer. In other words, the associated reduction in cancer mortality equates to abandoning two slices of bacon for breakfast and a 3-ounce steak for dinner, each day, for roughly two and a half decades.

* The associated per serving increase was not dose-dependent and disappeared after about an intake of 35–40 g of processed meat, or roughly 1 serving ([3] Supplement). ** Whole grain content can be difficult to calculate. The whole grain stamp (from the whole grain council) was used to estimate whole grain content of foods (https://wholegrainscouncil.org/find-whole-grains/stamped-products, accessed on 2 February 2023). † 100% whole grain stamp: all the grains in the food come from whole grains. ‡ 50% whole grain stamp: at least half of the grains in the food come from whole grains (many, but not all, 100% whole wheat breads have the 50% whole grain stamp). ◊ SSB serving size is most commonly defined as one standard glass, bottle, or can. SSBs are defined as caffeinated colas, caffeine-free colas, noncola carbonated sodas, and noncarbonated sugar-sweetened beverages, such as fruit punches, lemonades, or other fruit drinks. Note: fruit juice is not included as an SSB (although it is unclear if these drinks should also be included in the SSB label [26]). ® Roughly the length a person can sustain their VO_2 max. € Physical activity is more often measured via subjective report, in comparison to CRF or grip strength, which are directly measured. ¥ One MET hour = METs of an activity × duration of the activity (in hours). For examples of activities and their associated METs, use the 2011 Compendium of Physical Activities, easily accessible online.

2. Dietary Fiber

Increased dietary fiber intake appears to reduce one’s risk of cancer mortality. A large prospective cohort study performed in Europe showed an 18% reduction in cancer mortality when the highest quintile (≥28.5 g/d) was compared to the lowest quintile (<16.4 g/d), while correcting for several factors, including physical activity and calorie intake (adjustments for red meat intake did not change the associations and so were excluded from the final multivariate model), over a median follow-up of 12.7 years (HR = 0.82 [0.72–0.93] for men; HR = 0.82 [0.73–0.92] for women) [30]. Those in the highest quintile had a higher education level and were more physically active and appeared to eat more vegetables, larger amounts of red meat, and more calories compared to those in the lowest quintile of fiber intake. Fiber from cereals and vegetables, but not fruits, demonstrated reduced cancer mortality [30]. In another epidemiological study, this time based on a US cohort, Park et al. reported decreased cancer mortality in men (HR = 0.83 [0.76–0.92]) but not women (HR = 0.96 [0.85–1.08]) when the highest quintile of fiber intake was compared to the lowest [5]. There is some suggestion that the impact of fiber intake on cancer mortality might be dose-dependent with the greatest benefit conferred by increasing fiber consumption from low (< 13 g/day) to about 25 g of fiber per day [30]. This finding may explain why no statistical benefit was seen in women in the Park study as the highest quintile of fiber intake among women would have just met this threshold, with a median intake of 25.8 g per day.

It is worth noting that patients with the highest quintile of fiber intake in the Park et al. trial were more likely to have higher education, rate their health as very good/excellent, have a lower BMI, and be physically active, and were less likely to drink alcohol and consume red meat—all of which were corrected for using multivariate analysis. Although these characteristics were corrected for statistically, it is important to note the possibility of healthy-user bias in these studies as most baseline characteristics tend to favor the group already consuming the most fiber. Nevertheless, a pooled analysis of both of these studies demonstrated a 14% reduced risk in cancer death (HR = 0.86 [0.79–0.93]) when comparing those with high fiber intake to those with low fiber intake and a 6% reduced risk per 10-g per day increase of fiber intake (HR = 0.94 [0.91–0.97]) [4] (**Table 1**).

Using the data available from Park et al. [5], for every 49 people who currently eat less than 13 g of fiber per day, if they increase their daily fiber intake by 15–16 more grams—equivalent to five extra cups of strawberries, or an extra six cups of broccoli—one fewer cancer death would result over 9 years. This same group, should they increase their fiber intake by about 4 g per day—equivalent to one apple—one cancer death would be avoided per 77 people who adopt such a change.

3. Nuts

Using the NHS and HPFS, Bao at al. showed that nut consumption decreased cancer mortality by 11% in those that ate nuts five or more times per week vs. those that never ate nuts (HR = 0.89 [0.81–0.99]) [8]. Physical activity was higher in those that ate the most nuts. The authors mention that, based on the statistical assumptions, the benefit conferred by a confounder, such as physical activity, would have to be quite large to cancel out the signal for nut consumption's reduction in cancer mortality. For instance, there would need to be a 30% difference between groups, with a confounding variable that conferred a 50% reduction in risk, to negate the effect of the nut consumption.

In another large epidemiological trial examining the participants of the Physicians Health Study, Hshieh et al. showed that consuming nuts five or more times per week, compared to less than one serving per week did not result in a significant reduction in cancer deaths, but showed only a trend in reducing cancer mortality (HR = 0.87 [0.66–1.15]) [7]. By combining the Hshieh et al. study with the data from Bao et al., a meta-analysis demonstrated that high versus low nut consumption yielded a 14% reduction in cancer mortality (HR = 0.86 [0.75–0.98]) [6] (**Table 1**).

When using the numbers found in the Hshieh paper to approximate the absolute benefit of nut intake at the epidemiological level, about 124 people would have to eat five servings (equivalent to a handful) or more of nuts—about 120 almonds—per week, over roughly 10 years, to prevent one cancer death.

4. Whole Grains

Whole grains have also been associated with decreased cancer mortality [31][32], possibly related to the fiber content of whole grains [31]. A meta-analysis by Chen et al. demonstrated an 18% benefit per 50 g of whole grain intake (HR = 0.82 [0.69–0.96]) [9] (**Table 1**). As context, in the NHS, the highest quintile of whole grain intake was roughly 36 g, and for the HPFS, it was around 53 g per day [33]. Although this analysis of the NHS and HPFS cohorts demonstrated an associated decrease in all-cause (HR = 0.91 [0.88–0.95]) and cardiovascular (HR = 0.85 [0.78–0.92]) mortality in the highest versus lowest quintiles of whole grain intake, no difference was seen with respect to cancer mortality (HR = 0.97 [0.91–1.04]) [33]. Additionally, the most favorable study—with a hazard ratio of 0.64 [0.56–0.72] per 50 g increase of daily whole grains—that was included in the Chen et al. meta-analysis only showed an associated 7% reduction in cancer mortality when comparing the fifth and first quintiles of per day whole grain intake (HR = 0.93 [0.88–0.99]) [31]. This is possibly due to the fact that even some of the people in the fifth quintile of whole grain intake do not report consuming greater than 50 g of whole grains per day [31][33]. To give that statement context, 50 g of whole grains is equivalent to about three-quarters of a cup of cooked quinoa or three cups of Cheerios (**Table 1**). (Note that quinoa is likely a healthier option given that it is a more complete whole grain. One hundred percent of the grains in quinoa are considered whole, compared to at least 50% in Cheerios (**Table 1**).)

Although whole grain intake displays a relatively modest HR between the highest and lowest quintiles, the NNT for whole grains is quite low, at 38 people. This may be explained by the very low age-adjusted hazard ratio (HR = 0.63 [0.59–0.67]) for highest versus lowest quintile of whole grain intake [33]. The difference in the age-adjusted HR, and the more rigorously, multivariate adjusted HR (HR = 0.97 [0.91–1.04]), highlights the healthy user bias in this population, and clarifies the limitations of using the NNT metric in epidemiology. Nonetheless, an NNT of 38 means that 38 people would have to eat roughly a half to two-thirds of a cup of oatmeal per day for roughly 25 years to prevent one cancer death.

5. Fruits and Vegetables

Maybe somewhat surprisingly, a large and widely-cited meta-analysis did not show reduced cancer mortality with higher rates of fruit and vegetable (HR = 0.97 [0.90–1.03]), fruit (HR = 0.99 [0.97–1.00]), or vegetable (HR = 0.99 [0.97–1.01]) consumption [10] (**Table 1**). A separate meta-analysis suggests that for every 200 g of fruit and vegetable consumption per day (roughly ten spears of asparagus, or one large bell pepper), there is an associated 3% decrease in total cancer (total cancer includes both cancer incidence and cancer mortality) (HR = 0.97 [0.95–0.99]) [34]. The magnitude is small and the paper does not comment on cancer mortality specifically. Overall, the results of this more recent meta-analysis are consistent with the first meta-analysis; the two studies support the idea that fruit and vegetable consumption are either not associated with improved cancer mortality or minimally so.

6. Other Foods

Before turning to exercise, it is important to mention that the relationship between cancer mortality and other food groups has also been studied and several different meta-analyses have been conducted (fish and poultry [11], dairy [13], eggs [16][35], legumes [14], and sugar-sweetened beverages (SSBs) [18][36]). No improvement in cancer mortality was seen between high versus low consumers of either fish (HR = 0.99 [0.94–1.05]) or poultry (HR = 0.96 [0.93–1.00]) [11], total dairy consumption (HR = 0.99 [0.92–1.07]) [13], or legumes (HR = 0.85 [0.72–1.01]) [14] (**Table 1**). Although a linear dose-response was not seen between intake of SSBs and cancer mortality [18][36], when looking at the highest versus the lowest consumers of SSBs (roughly two 12 ounce cans per day vs. <one can per month) there was an associated 6% increase in cancer related deaths (HR = 1.06 [1.01–1.12]) [18] (**Table 1**). As for eggs, when comparing the highest versus lowest egg intake categories, there was a 20% increased risk in cancer mortality (HR = 1.20 [1.04–1.39]; however, there was no increase in all-cause mortality, cardiovascular disease, coronary heart disease, stroke, or respiratory disease [16]. Importantly, the highest quintile of egg intake equals approximately half an egg per day [17]. In other words, the associated benefit from reducing egg intake stems from decreasing one's omelet intake, roughly three eggs, from four times a month to once a month (**Table 1**).

7. A Grain of Salt

Lastly, some articles with respect to nutrition make very granular associations. These associations can be hard to interpret. For instance, every serving of whole milk per day increases prostate cancer mortality by 43% (HR = 1.43, [1.13–1.81]), but additional servings of total dairy (HR = 1.00 [0.97–1.04]), milk (HR = 1.02, [0.97, 1.08]), yogurt (HR = 0.6 [0.29–1.26]), cheese (HR 1.23 [0.76–1.99], butter (HR = 0.9 [0.45–1.80]), and skim/low fat milk (HR = 1.07 [0.95–1.20]) consumption do not [13]. At face value, the near 50% increase in prostate cancer mortality, per glass of whole milk, appears impressive; however, it is difficult to know what to do with this information. Should most men stop drinking whole milk? With a lack of association between other dairy products and no clear mechanism to explain this phenomenon—the mechanisms presented in the paper are not terribly convincing—it is truly difficult to draw an actionable conclusion in this instance.

These comments are not to minimize the importance of nutrition, but rather to highlight some of the limitations within nutritional epidemiology. By understanding such pitfalls, solitary examples, such as the one above, become less important and consistent patterns and repeated associations assume priority. With that said, the relative risks from foods that do showcase a more consistent association with cancer mortality (chose any of the previously mentioned foods) tend to be small. Whether the association with cancer mortality is detrimental (HRs in the vicinity of ~1.1–1.2) or favorable (HRs in the ~0.85–0.95 ballpark), the hazard ratio does not deviate far from 1, and that is when a risk or benefit exists. These ratios will be important to remember when turning to exercise, especially when considering cardiorespiratory fitness.

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