Food Fiber & Other Indigestibles

Edwin Cox, M.D.
OLLI What To Eat & Why!

Objectives

- Describe dietary fiber (indigestible carbohydrate) and its food sources
- Review evidence relating fiber consumption to health outcomes, including cardiovascular disease and mortality
- Discuss other indigestibles – the statistical tools (survival analysis) used to analyze nutritional epidemiology data – and illustrate their use

What is dietary fiber?

- Dietary fiber is indigestible carbohydrates (polysaccharides)
  - Digestible carbs are sugars and starches
  - Specific enzymes break sugars and starches into glucose, which gets absorbed
  - Lacking enzymes for longer, more complex polysaccharides, fiber passes to colon intact
- Insoluble fiber
  - Cellulose, lignins, others
  - Passes out of colon intact, binds bile salts, adds bulk to stool
- Soluble fiber
  - Feedstock for intestinal micro-organisms (“gut microbiome”)
  - Products of fermentation include many compounds that are beneficial to the colon and body: short-chain fatty acids providing energy, immune signaling, psychoactive compounds

Sources of dietary fiber

- Whole grains
  - Wheat, barley, quinoa, rice, corn, aramanth, ...
  - Fiber is in the kernel
  - Processed grains have the fiber removed
- Fruits
- Vegetables
- Pulses (AKA legumes, beans)
- Nuts
- Seeds

Fiber ca. 1960’s knowledge

- Useful for treating constipation, irritable bowel, and similar intestinal problems
- Adjunct for lowering cholesterol level by removing bile salts before they recirculate
- Psyllium seed (Metamucil) was the main preparation recommended; inulin, dextran
- Fruits and vegetables contain substantial amounts of fiber, and we know they are good for us
- Fiber slows intestinal absorption, reducing glucose spikes and resulting insulin spikes
- Beans are “good for the heart”, but are hard to digest and bring on undesirable side effects (“the musical fruit”)

Fiber ca. 2016 knowledge

- Fiber feeds our gut microbiome
  - The human “meta-organism”: human + microbiome
  - Gut microbiome considered by some to be an endocrine organ
  - Food for our microbiome given the name “prebiotics”
- The quality of what we feed our microbiome is a key determinant of how well it functions on our behalf
  - More about the microbiome and its functions in a later session

Vegetarianism and fiber

- The emergence of the vegetarian diet and its apparent health benefits focused attention on fiber
  - Seventh Day Adventists were major adherents of vegetarian diets
  - Longevity was somewhat greater in Adventists than the general population
  - Loma Linda University, in the heart of California Adventist population, began systematic study of disease incidence and mortality relative to diet in 1950s with the support of the NIH
  - Fiber is a major aspect of plant-based foods

Fiber and mortality

- First studies to go beyond effects of fiber on heart disease to effects on overall mortality emerged around 2000
  - Scottish Heart Health Study
  - Zutphen Study (Netherlands)
  - Israeli study
  - All showed inverse relation between amount of fiber consumed and mortality, i.e., lower mortality with increasing dietary fiber
- NIH-AARP Study
  - Largest, most detailed to date

Fiber & mortality: NIH-AARP

Dietary fiber intake and mortality in the NIH-AARP Diet and Health Study

Yikyung Park, Sc.D[1], **Amy F. Subar, Ph.D.**[2], **Albert Hollenbeck, Ph.D**[3], and **Arthur Schatzkin, MD**[1]

[1]Nutritional Epidemiology Branch, Division of Cancer Epidemiology and Genetics, National Cancer Institute, Rockville, MD

[2]Division of Cancer Control and Population Sciences, National Cancer Institute, Rockville, MD

[3]AARP, Washington, DC

Park et al Arch Int Med 2011

Fiber & mortality: NIH-AARP

Invitation to participate went to half a million AARP members in 6 states and two metro areas responding to questionaire in 1995-96

219,123 men & 168,999 women eligible, ages 50-71

Follow-up 9 years avg.

Excluded: existing cancer, heart disease, diabetes, stroke

Food frequency questionaire – 124 items

Lifestyle data: Smoking, exercise, personal and family medical history, HRT, BMI, alcohol, ASA, education

Fiber & mortality: NIH-AARP

Cases

- Men: 5,248 CVD & 8,244 cancer deaths
- Women: 2,417 CVD & 4,917 cancer deaths

Deaths per 100,000 from all-cause, CVD & cancer (age-adjusted)

- Men: 991, 258, 406
- Women: 716, 153, 311

Analysis

Separate men and women, in case there are important differences

Divide into equal size groups - "quantiles"

- Two groups: halves; three: tertiles; four: quartiles
- Five groups: quintiles – 219,123/5 = 43,824 men per quintile

Examine changes in outcome (mortality) across the groups

Formal statistical test of trends (change in mortality with increasing fiber)

Multivariate analysis (MVA) to account for possible effects of other factors ("covariates")

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Selected characteristics of study participants by categories of dietary fiber intake

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	Quintile 1	Quintile 3	Quintile 5	Quintile 1	Quintile 3	Quintile 5
Median dietary fiber intake (g/day)	12.6	19.4	29.4	10.8	17.0	25.8
Age at baseline [a]	61	62	62	61	62	62
White, non-Hispanic (%)	92	94	91	90	91	88
College and post college (%)	38	47	53	24	32	37
Married (%)	82	87	84	42	47	45
Excellent, very good health (%)	55	62	70	50	58	65
Body mass index [a]	27.3	27.2	26.4	26.8	26.6	25.6
Vigorous physical activity, ≥3 times/wk (%)	35	49	64	27	42	58
Former smoker (%)	50	55	54	33	38	41
Current smoker (%)	22	9	4	28	12	6
Current menopausal hormone therapy use (%)	-	-	-	41	47	47
Alcohol (g/day)[a]	27	19	9	12	5	3
Red meat (g/1,000 kcal)[a]	47	40	25	38	30	18
Total energy intake (kcal/day)[a]	2,019	2,084	1,969	1,565	1,573	1,524

[a]Mean values

Fiber & mortality: NIH-AARP

Men and women who consumed more fiber

- more educated
- rated their general health higher
- smoked less
- consumed less alcohol
- ate less red meat
- lower BMI

Table 2

Relative risks and 95% confidence intervals of total death for quintiles of dietary fiber intake in men and

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Body mass index[f]						
<25 (n=6307)	1.00	1.00 (0.93–1.08)	0.95 (0.87–1.03)	0.86 (0.78–0.94)	0.82 (0.74–0.92)	<0.001
25–<30 (n=8961)	1.00	0.93 (0.87–0.99)	0.92 (0.86–0.99)	0.82 (0.76–0.89)	0.79 (0.72–0.86)	<0.001
≥30 (n=4148)	1.00	0.86 (0.78–0.94)	0.79 (0.71–0.87)	0.78 (0.70–0.87)	0.74 (0.65–0.84)	<0.001

Relative risk of total death ???

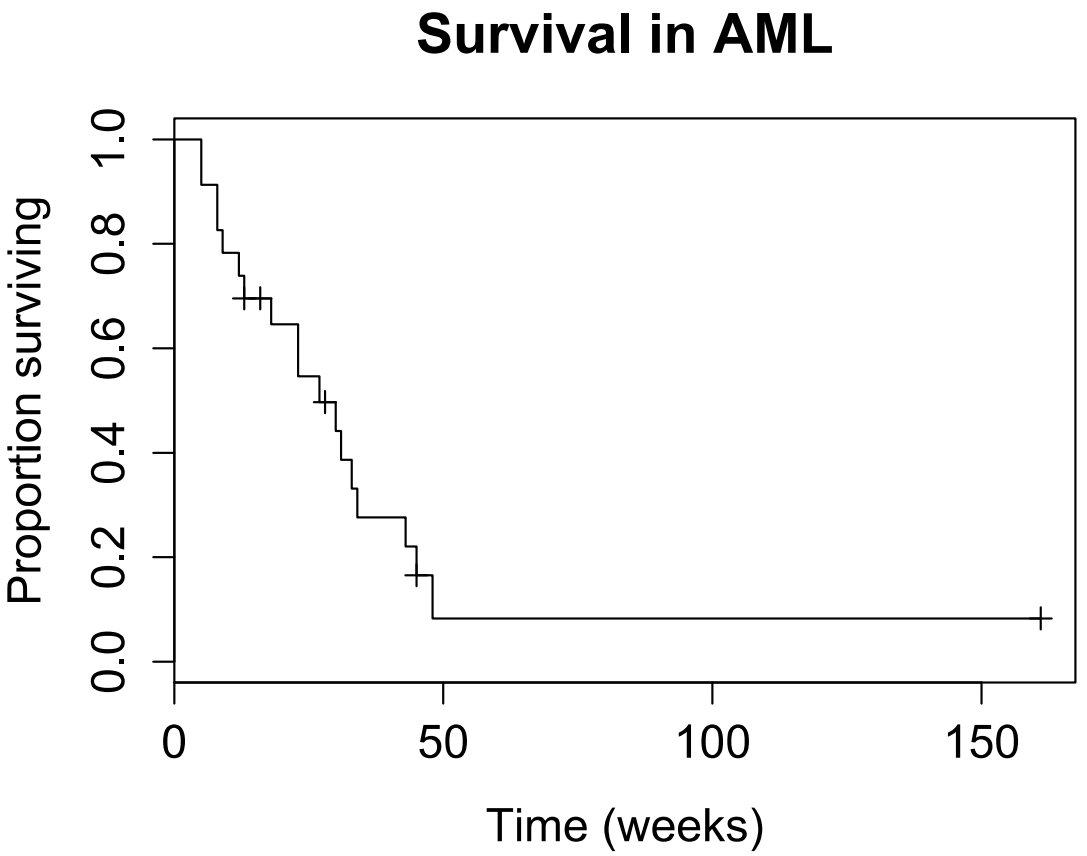
Risk? Death? Sounds grim...

Set of analytic techniques geared toward determining the rate and causes of failure (death, onset of disease, relapse from remission, failure of an electrical component)

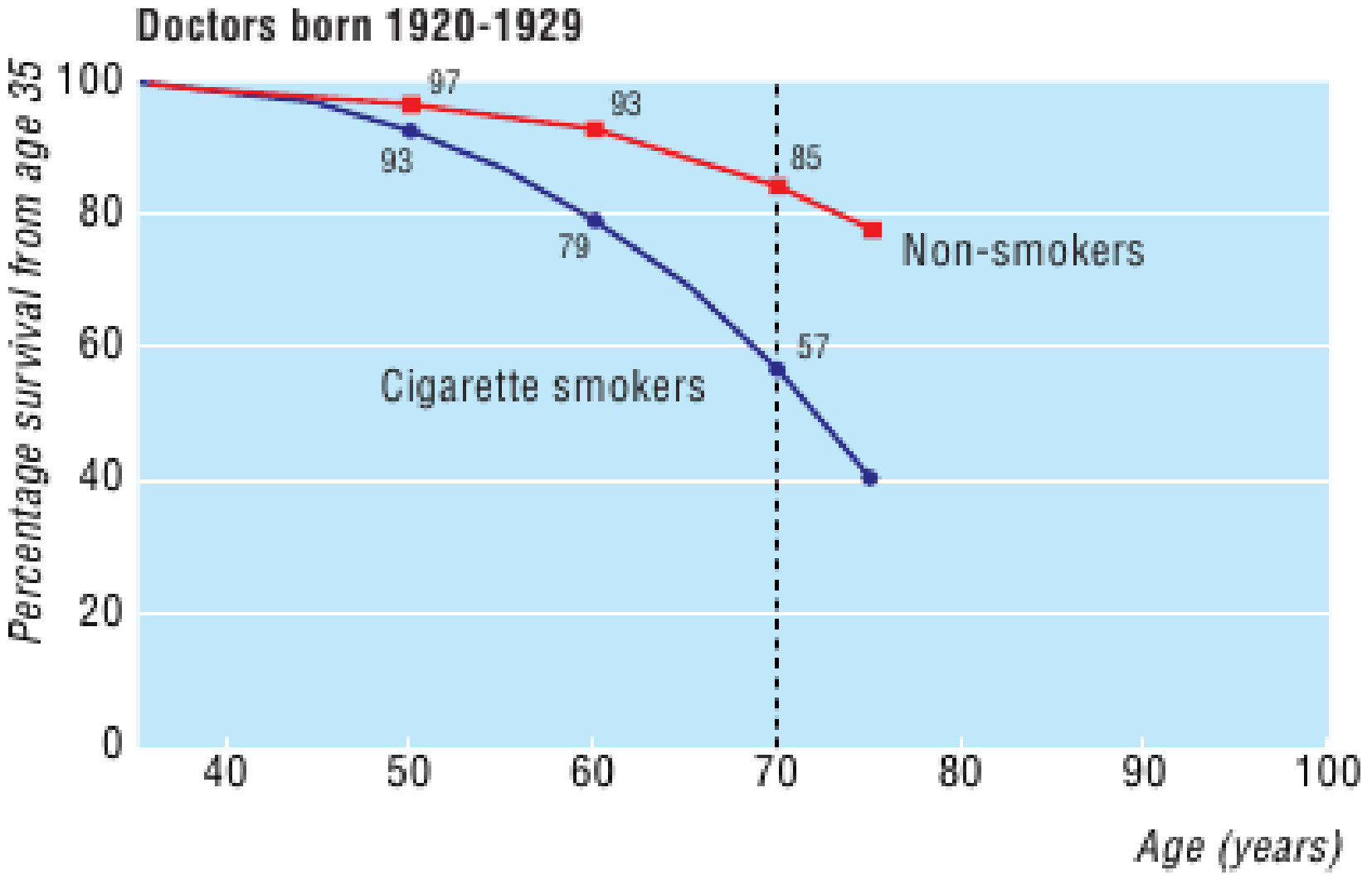
Time to take a detour to acquire some new tools: survival analysis

Life Table:
Leukemia Disease-Free Survival

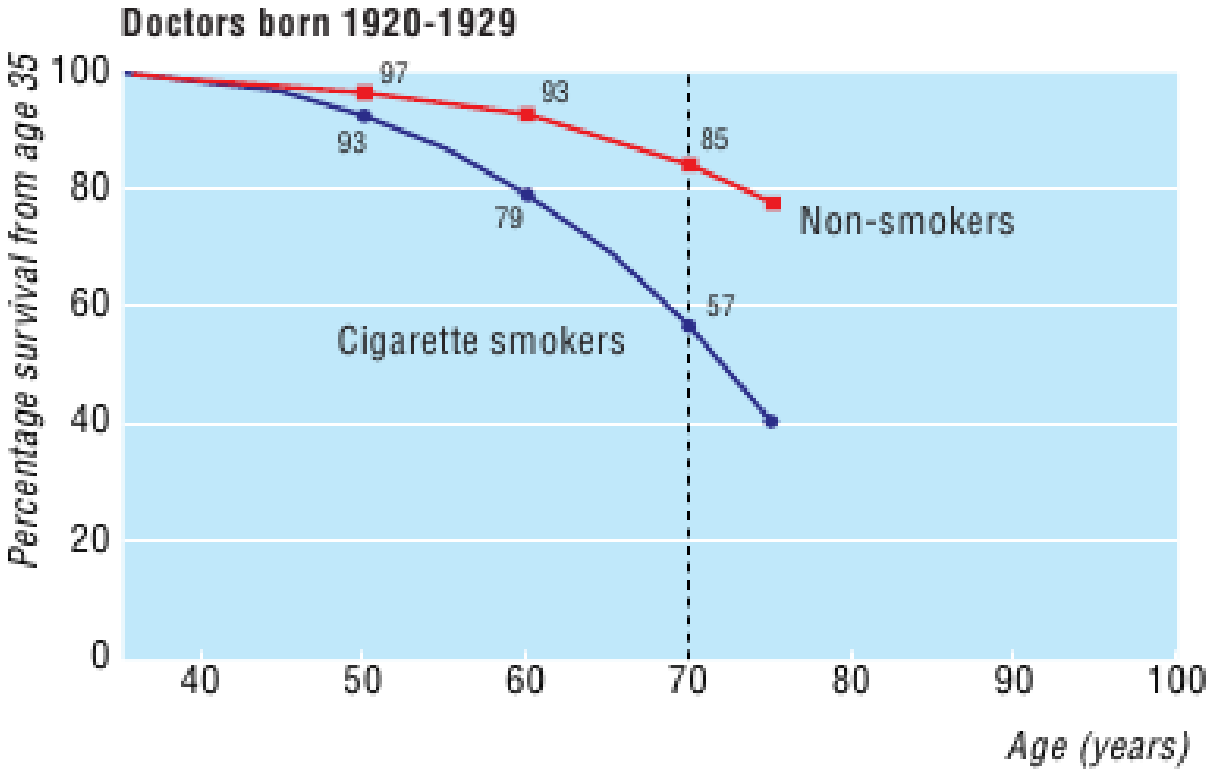
observation	time (weeks)	status	x
12	5	1	Nonmaintained
13	5	1	Nonmaintained
14	8	1	Nonmaintained
15	8	1	Nonmaintained
1	9	1	Maintained
16	12	1	Nonmaintained
2	13	1	Maintained
3	13	0	Maintained
17	16	0	Nonmaintained
4	18	1	Maintained
5	23	1	Maintained
18	23	1	Nonmaintained
19	27	1	Nonmaintained
6	28	0	Maintained
20	30	1	Nonmaintained
7	31	1	Maintained
21	33	1	Nonmaintained
8	34	1	Maintained
22	43	1	Nonmaintained
9	45	0	Maintained
23	45	1	Nonmaintained
10	48	1	Maintained
11	161	0	Maintained



Longevity UK Doctors at Age 35



Mortality of British Physician Non-Smokers						
Ages	Fraction	Survival	# Years	Survival /yr	Mortality	#/1000/yr
		S	N	$S^{1/N}$	MR, /yr	MR
35-50	97/100	0.970	15	0.99797	0.00203	2.0
50-60	93/97	0.959	10	0.99582	0.00418	4.2
60-70	85/93	0.914	10	0.99105	0.00895	9.0



$S_{a,b}$ means “probability (P) of surviving to age *b*, given that you got to age *a*”

$S_{35,36}$ means “P of surviving to age 36, given that you lived to age 35”

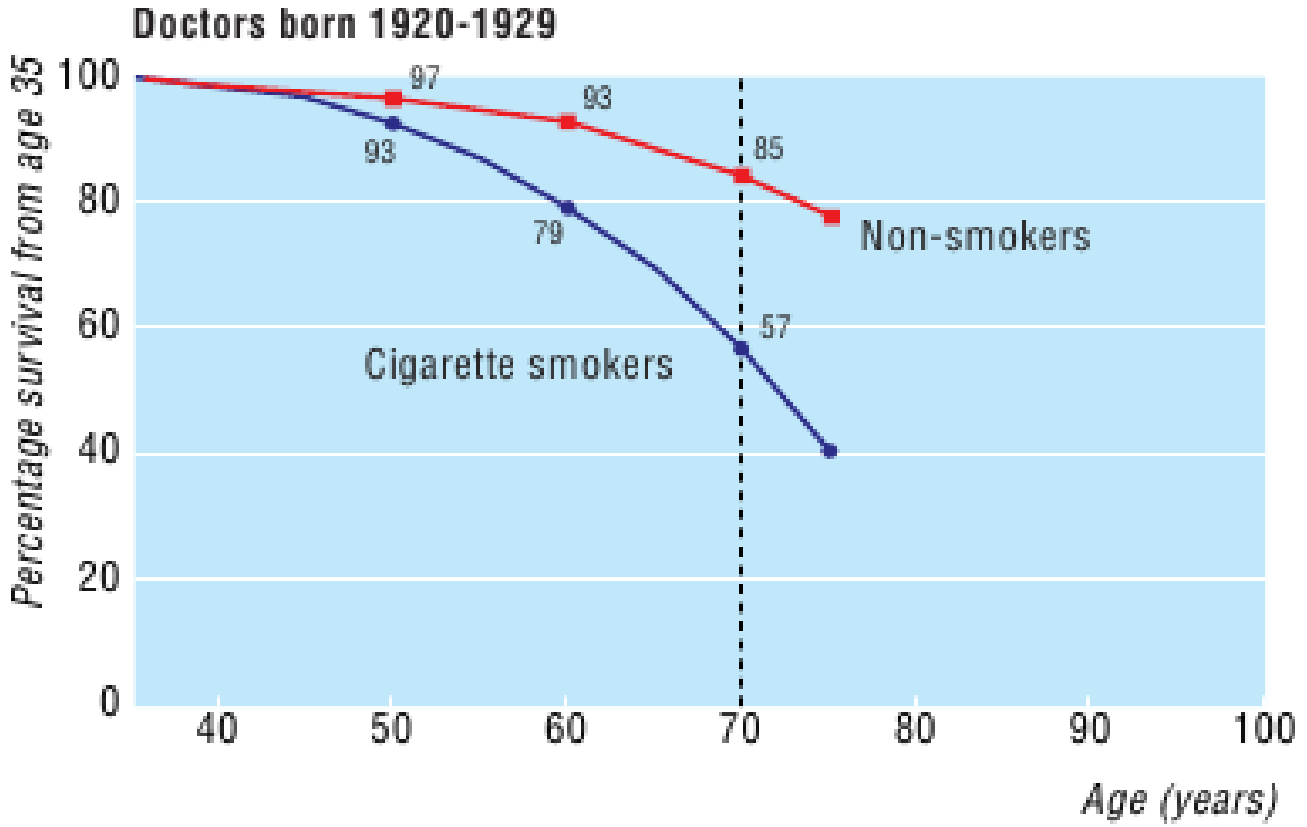
$S_{35,40}$ means “P of surviving to age 40, given that you lived to age 35”

$S_{35,40} = S_{35,36} \times S_{36,37} \times S_{37,38} \times S_{38,39} \times S_{39,40}$

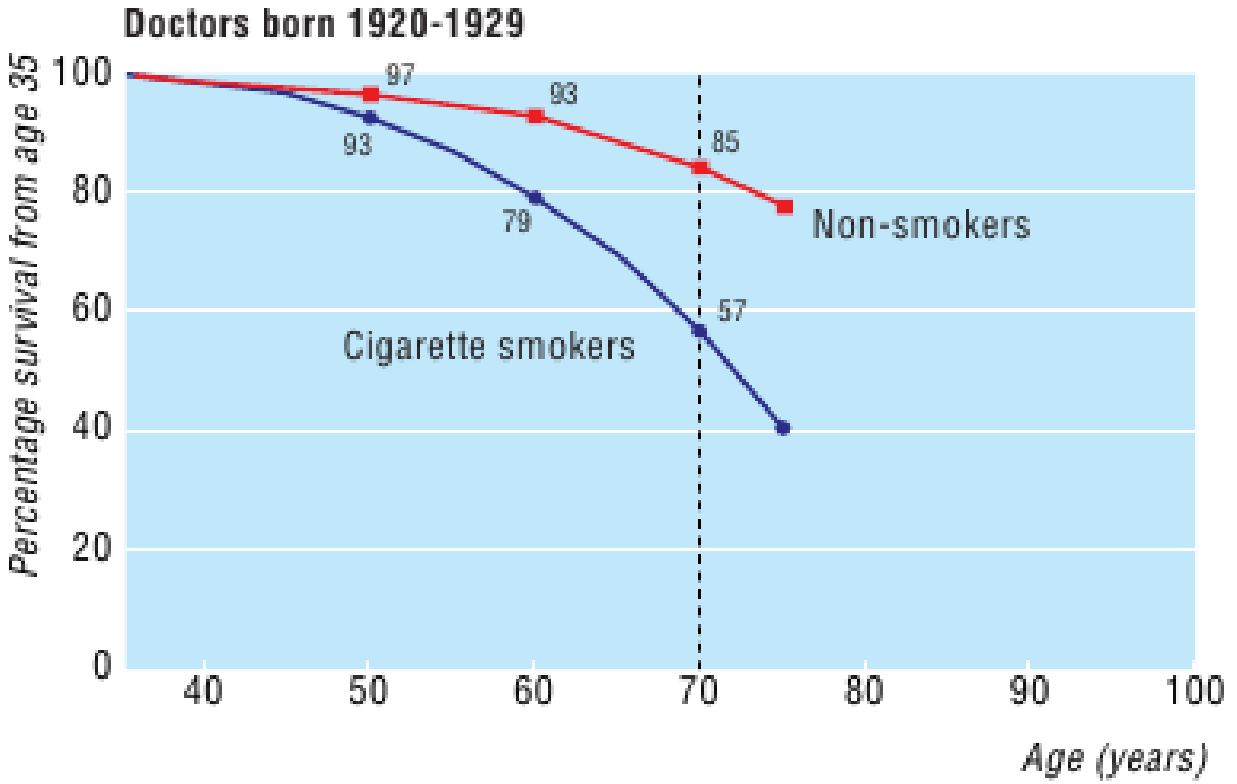
If each annual $S_{a,b}$ is approximately equal, $S_{35,40} = S_{a,b}^{5}$

If we know $S_{35,40}$, we can estimate $S_{a,b} = S_{35,40}^{1/5}$, the 5^{th} root of $S_{35,40}$

Mortality of British Physician Smokers						
Ages	Fraction	Survival	# Years	Survival /yr	Mortality rate	#/1000/yr
		S	N	$S^{1/N}$	MR, /yr	
35-50	93/100	0.930	15	0.99517	0.00483	4.8
50-60	79/93	0.849	10	0.98376	0.01624	16.2
60-70	57/79	0.722	10	0.96789	0.03211	32.1



Relative Risk of Death: British Physician Smokers vs. Non-Smokers by Age Group			
Ages	Non-smokers	Smokers	Relative risk
	#/1000/yr	#/1000/yr	$RR=MR_{smoker}/MR_{nonsmoker}$
35-50	2.0	4.8	2.4
50-60	4.2	16.2	3.9
60-70	9.0	32.1	3.6



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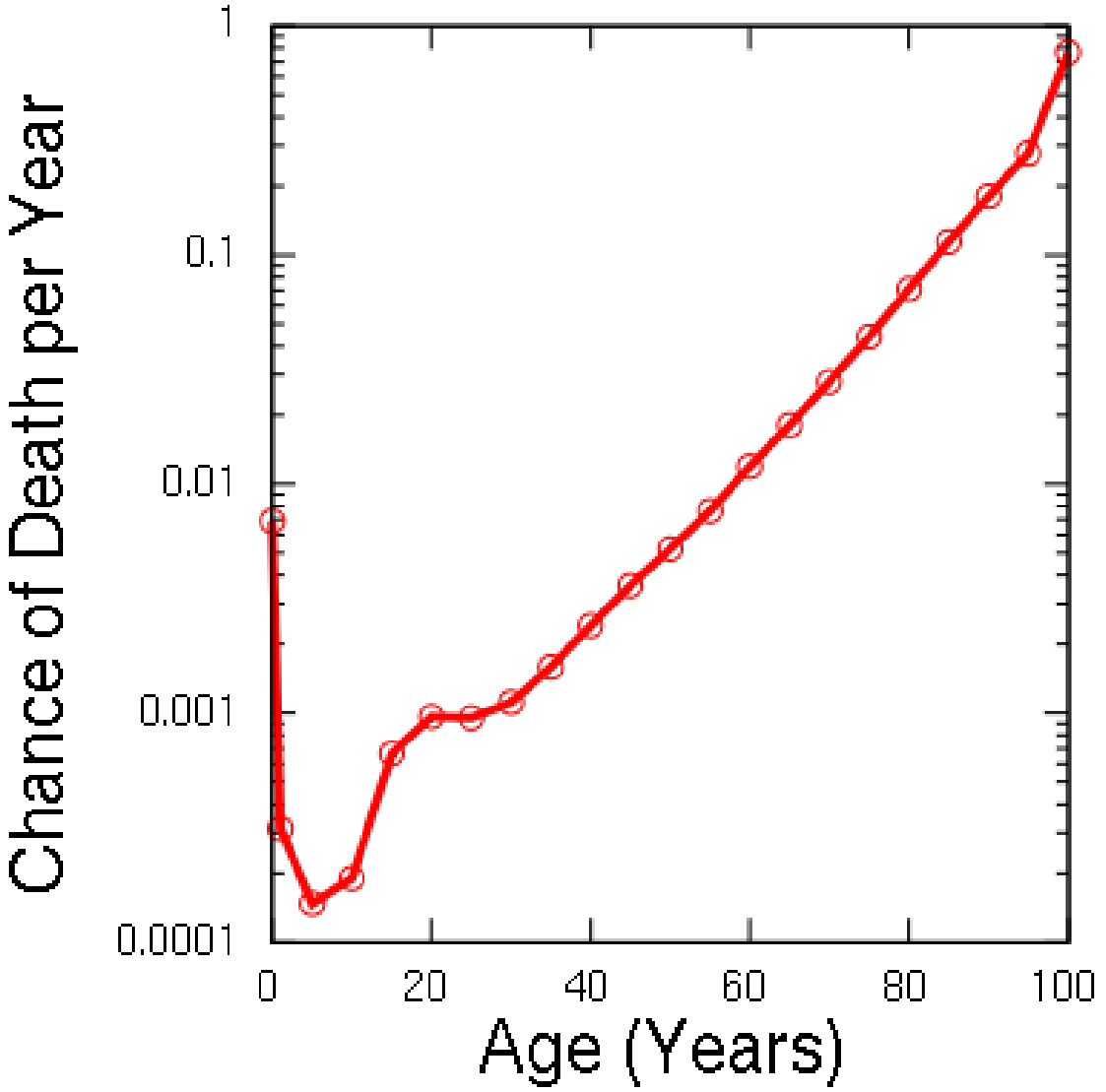
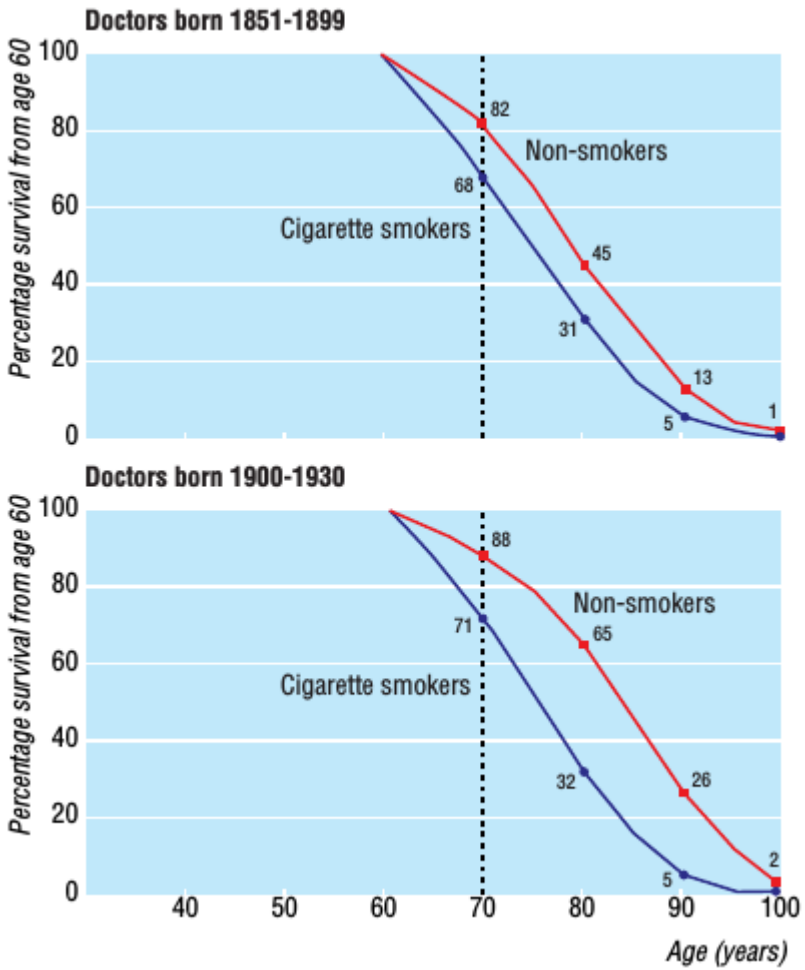
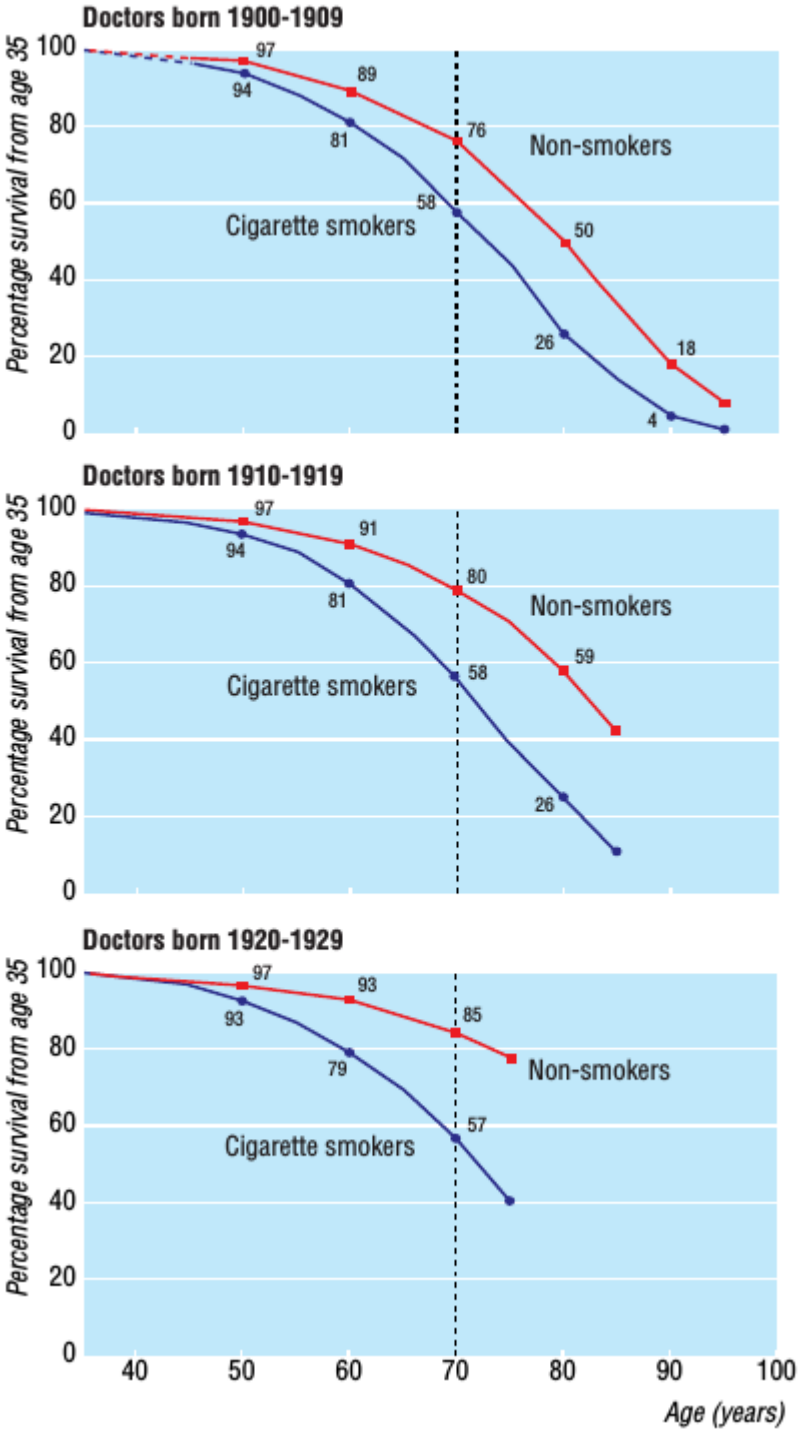
U.S. Mortality Rates by Age





Smoking MDs got none of the benefits of increasing survival that accompanied improvements in public health and medical care from 1800s into mid 1900s!



Confidence intervals

95% confidence interval

- With 95% confidence, the true mean value of the underlying distribution lies within this interval
- Depends jointly on sample size and variability within data
- If a specified non-significant value (1.0 for RR) is covered by the 95% CI, the difference from that value is not statistically significant

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Forest plots

Compact graphical depiction of RR and 95% CI

Combining data from multiple studies: Meta-analysis

Comparing data from multiple factors

Icon size indicates relative number of subjects

Horizontal line spans CI, usually 95% CI

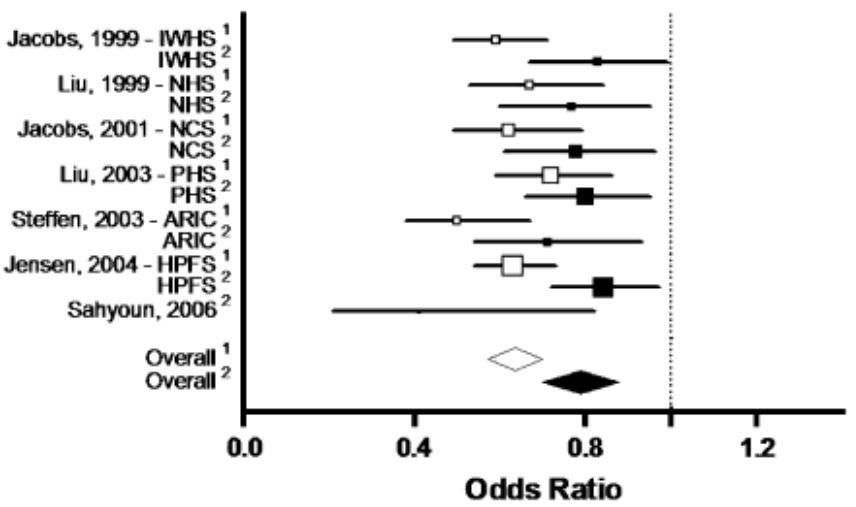
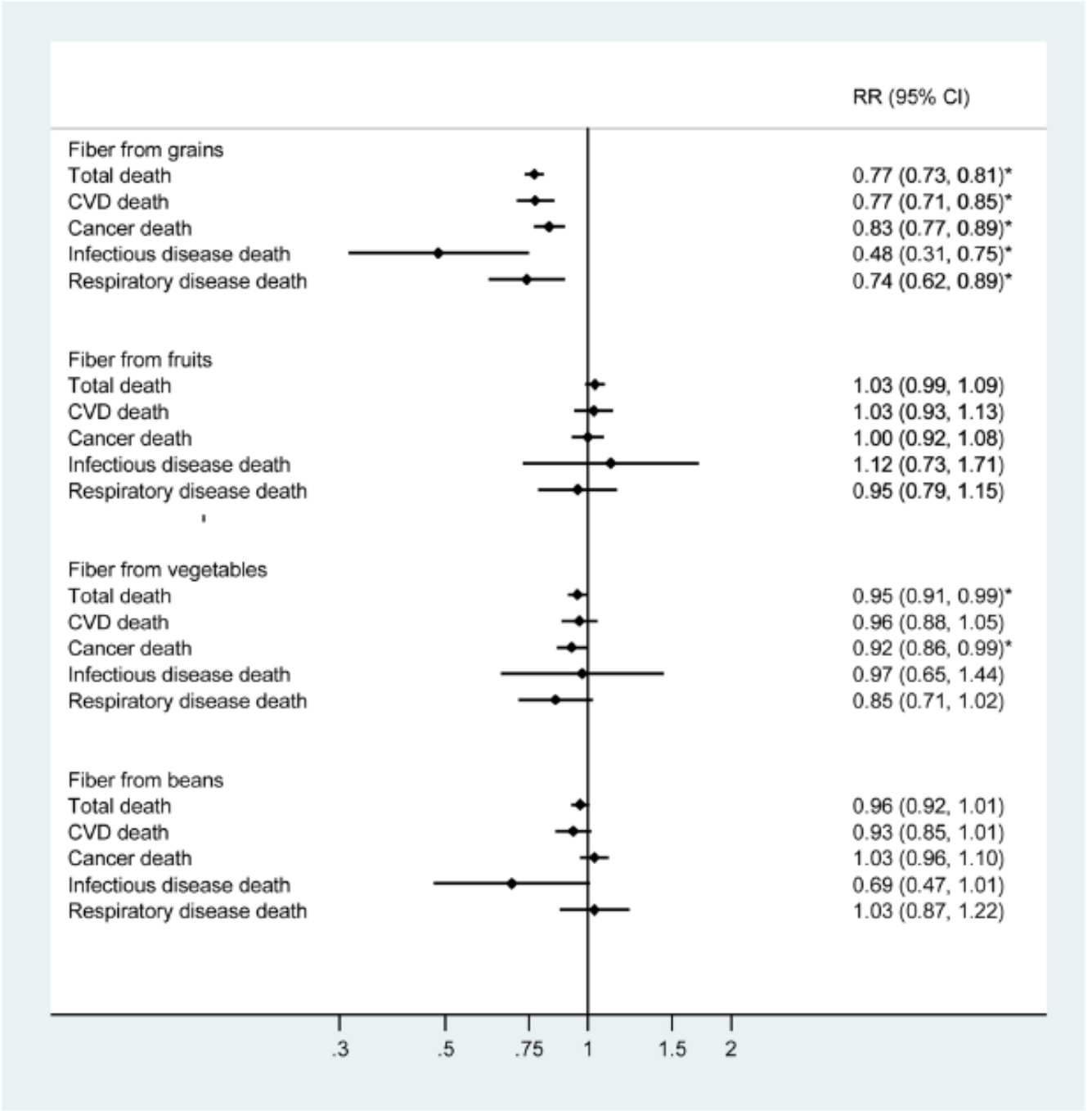


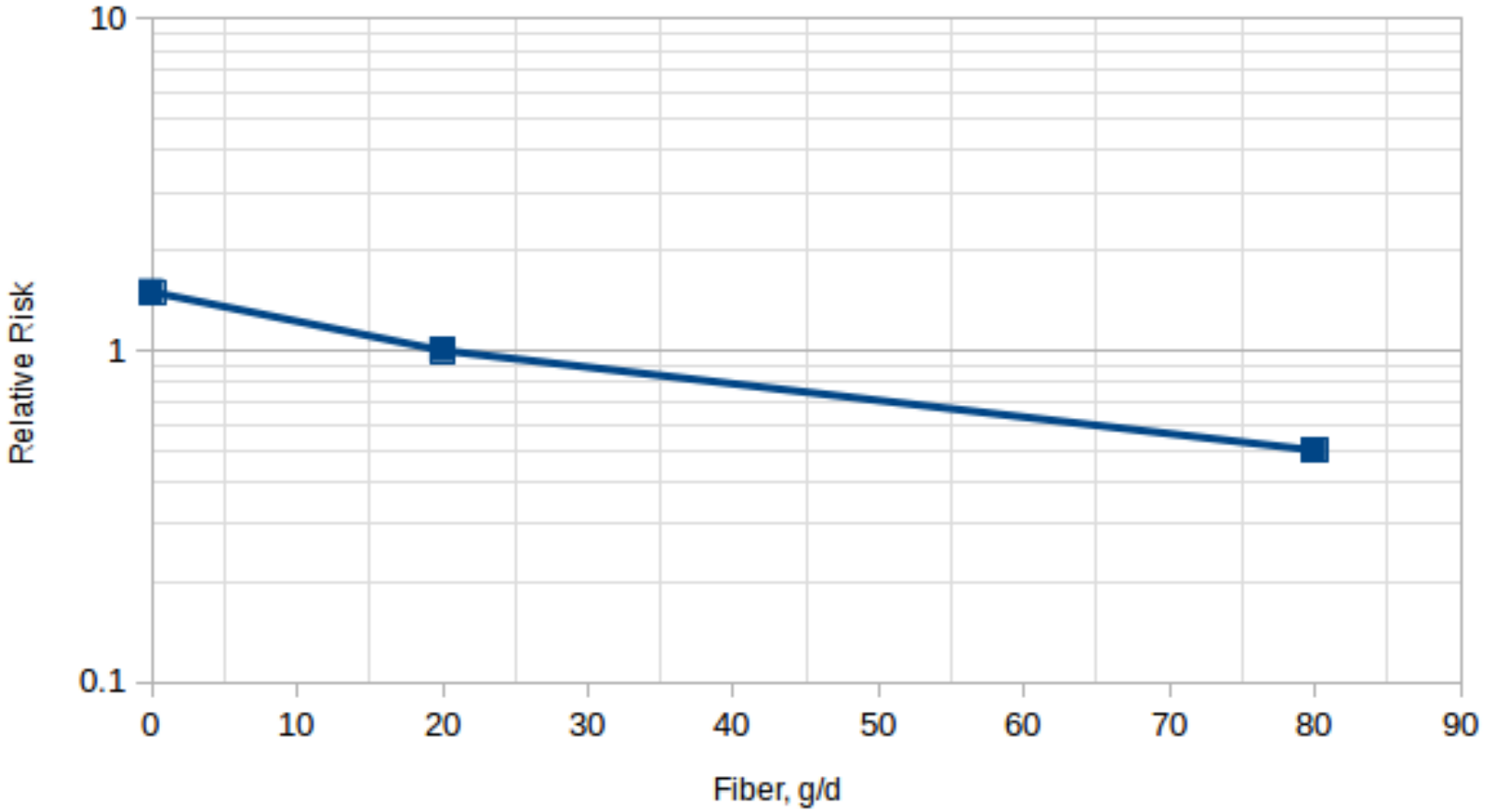
Figure 1 Odds ratios of incident cardiovascular disease, comparing high versus low whole grain intake. Abbreviations: IWHS — Iowa Women's Health Study; NHS — Nurses' Health Study; NCS — Norwegian County Study; PHS — Physicians' Health Study; ARIC — Atherosclerosis Risk in Communities; HPFS — Health Professionals' Follow-up Study. [1]Demographic-adjusted model. [2]Demographic + risk factor adjusted model.

A. men



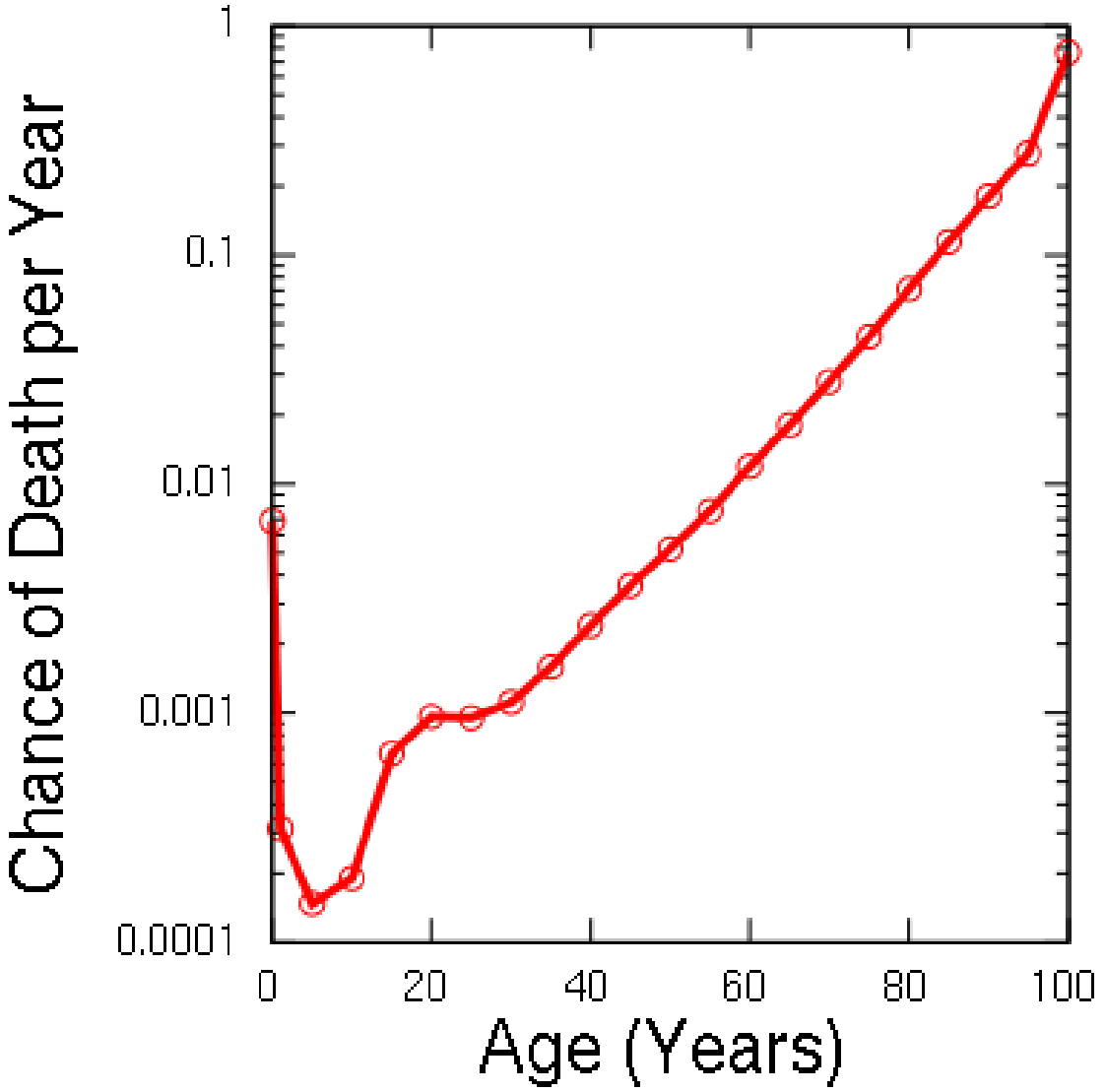
* P-trend <0.05

Relative risk vs. amount of fiber



Threapleton BMJ 2013 Meta-analysis

U.S. Mortality Rates by Age



Effect of fiber on mortality

If true, going from lowest daily intake (~0) to very high intake (80 g/d) is associated with mortality decrease equivalent to setting back the biological clock 1.5 decades!

However...

- Plot I showed was RR of onset of cardiovascular disease vs. fiber amount
- Plot was extrapolated beyond range of actual data

Linear regression analysis

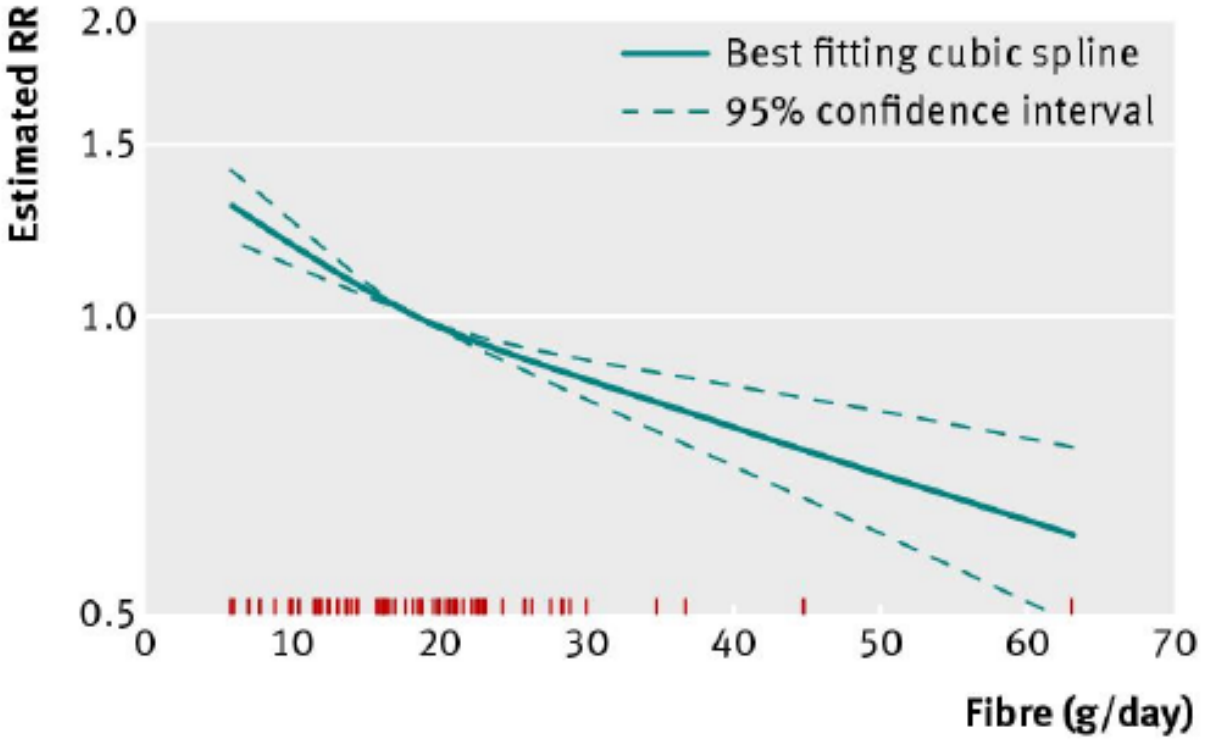


Fig 2 Risk of CHD across increasing levels of total fibre intake. RR=risk ratio

$$\log(RR) = a + bx$$

Multiple linear regression

Estimate the relationships of multiple cofactors on the outcome variable concurrently

- $y = \Sigma a_i x_i$

Adjusting for the effects of confounding cofactors (correlated)

- Those eating more fiber are less likely to smoke

Stepwise regression

- Enter covariates into the model, one at a time, to obtain greatest amount of variance explained

Proportional hazards multiple regression

Relative risk also known as relative hazard

Hazard functions may vary with time

- U.S. survival vs. age: Hazard rate increases exponentially (doubles with each decade of life)

Outcome variable is $\log(h(t)/h_o(t))$, i.e., the log of the hazard ratio

Hazard function need not be known or specified, as long as proportional hazard qualification reasonably well met

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Multivariate II[c]	1.00	0.94 (0.90–0.98)	0.90 (0.86–0.94)	0.82 (0.78–0.87)	0.78 (0.73–0.82)	<0.001
Smoking status[d]						
Never smokers (n=3877)[e]	1.00	0.96 (0.86–1.08)	0.96 (0.86–1.08)	0.84 (0.74–0.95)	0.81 (0.71–0.93)	<0.001
Former smokers (n=10777)	1.00	0.91 (0.86–0.97)	0.87 (0.82–0.93)	0.81 (0.76–0.87)	0.76 (0.70–0.82)	<0.001
Current smokers (n=4502)	1.00	0.99 (0.91–1.07)	0.96 (0.88–1.06)	0.85 (0.76–0.95)	0.82 (0.70–0.95)	0.003
Body mass index[f]						
<25 (n=6307)	1.00	1.00 (0.93–1.08)	0.95 (0.87–1.03)	0.86 (0.78–0.94)	0.82 (0.74–0.92)	<0.001
25–<30 (n=8961)	1.00	0.93 (0.87–0.99)	0.92 (0.86–0.99)	0.82 (0.76–0.89)	0.79 (0.72–0.86)	<0.001
≥30 (n=4148)	1.00	0.86 (0.78–0.94)	0.79 (0.71–0.87)	0.78 (0.70–0.87)	0.74 (0.65–0.84)	<0.001

Fiber Rule of 10%

We get about 1000 calories / day from carbs (50% of 2000 Kcal)

That's 250 g of carbs (1000 g / 4 cal per g)

We're aiming for 25 g of fiber / day

25/250 is 10%

If we eat carbs where fiber is 10% or more of total carbs, we will get 25 g of fiber / day

- White pasta has 2 g fiber, 40 g total carb per serving → 5% fiber
- Whole grain pasta has 5 g fiber, 40 g carb per serving → 12.5% fiber
- Whole grain pasta contributes a good share, white pasta not so much

Data needed is on Nutrition Facts label on package

Fiber content of various foods

Product	Serving (g)	Total Carbs (g)	Fiber (g)	1/10 Rule	Quantity
Tostitos	28	19	1	0.53	7
Bob's Red Mill Wheat Bran	15	10	6	6.00	¼ c
Harris Teeter Organics Whole Wheat Couscous	42	30	3	1.00	¼ c
Near East Couscous	62	46	2	0.43	1/3 c
Barilla White Fiber Penne	56	43	6	1.40	
Trader Joe's Harvest Grains	45	34	2	0.59	¼ c
Uncle Ben's Whole Grain Brown Rice	48	36	2	0.56	¼ c
Mueller's Hearty Homestyle Egg Noodles	56	40	2	0.50	1-1/2 c
Carrington Farms Chia Seeds	12	4	4	10.00	2 T
Mueller's 100% Whole Grain Wide Ribbons	56	40	5	1.25	1-1/4 c
Flax USA Organic Golden Flax	14	5	4	8.00	2 T
Minute Multigrain Medley	43	33	2	0.61	
All Purpose Flour	30	22	0	0.00	¼ c
King Arthur White Whole Wheat Flour	30	18	3	1.67	¼ c
Nature Valley Oats 'n Honey Bar	42	29	2	0.69	2 bars
La Banderita Flour Tortilla	45	22	1	0.45	
Luck's Black Beans	130	19	5	2.63	1/3 c
Progresso Southwestern Style Vegetable Soup	242	12	4	3.33	1 c
Wild Oats Crunchy Peanut Butter	32	8	2	2.50	2 T
Kirkland Mixed Nuts	30	7	2	2.86	¼ c