An Introduction to Clinical Trials: Design Issues

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Type of Studies

- Non-experimental (Observational)
  - Case report
  - Case series
  - Cross-sectional (survey)
  - Case-control
  - Prospective, observational (cohort)
- Experimental
  - Randomized, clinical trial (RCT)

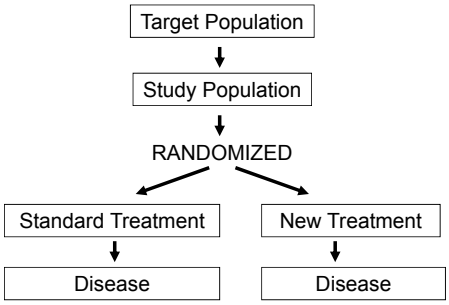
Study designs

- Observational studies:
  - **Observe** both exposures and outcomes
- Experimental studies (clinical trials)
  - **Assign** exposures
  - **Observe** outcomes

Advantages of Clinical Trials

- Often provides the strongest evidence in support of cause-effect relationships
- Basis for clinical and public health policy
- Minimize/eliminate bias and confounding

Randomized Clinical Trial



Comparison of Study Designs

	Type of Study Design			
Dimension	**Cross-Sectional**	**Case-Control**	**Cohort**	**RCT**
Estimate Prevalence	A	-	B	-
Estimate Incidence	-	-	A	B
Prove Causality	C	B-	B+	A
Generalizability	A	B+	B+	B
Feasability	A	A	B	C

Core Elements of a Clinical Trial

- Research Question
- Hypotheses
- Core Design
- Study Participants
- Recruitment
- Allocation
- Masking (Blinding)
- Treatment Groups
- Data
- Analytical Issues
- Interpretation of Results

The Research Question

- Critical in the design of a trial
- Types of questions:
  - Assessing efficacy of an intervention
  - Assessing the effectiveness of an intervention

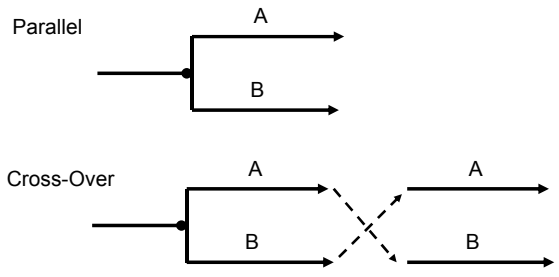
Types of Hypotheses

- Comparative Trial (a.k.a. Superiority Trial)
  - Objective: to demonstrate that a new therapy (n) is superior to standard therapy (s) in terms of incident outcome (I)
    - H_O: $I_n = I_s$
    - H_A: $I_n < I_s$ (one tailed) or H_A: $I_n \neq I_s$ (two tailed) at some minimally detectable Δ judged to have clinical significance

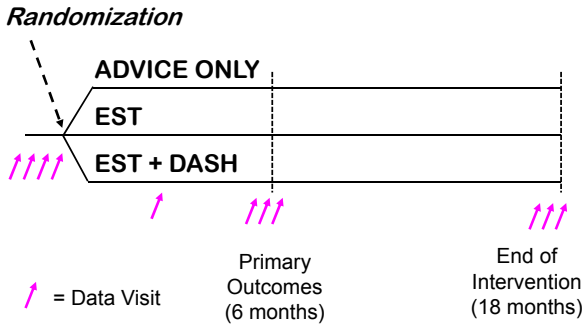
Types of Hypotheses

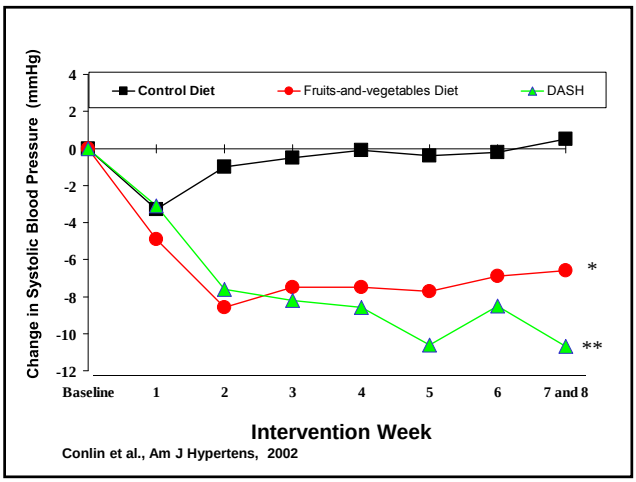
- Equivalence (non-inferiority trial)
  - Objective: to demonstrate that a new therapy (n) is no worse than standard therapy (s) in terms of incident outcome (I)
    - H_O: $I_n > I_s$
    - H_A: $I_n = I_s$ at some Δ, the maximum tolerable difference considered to be clinically acceptable

Basic Types of Design



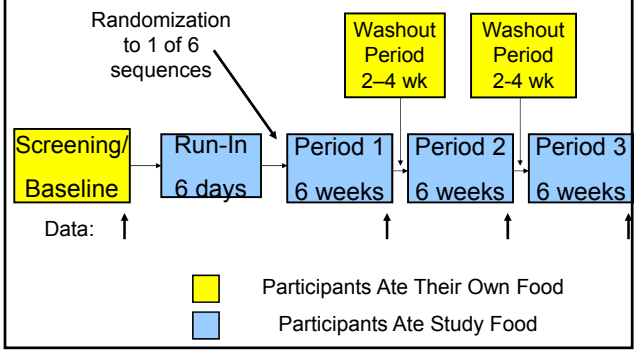
Parallel Study Design (PREMIER)





Conlin et al., Am J Hypertens, 2002

Cross-Over Study Design (OmniHeart)

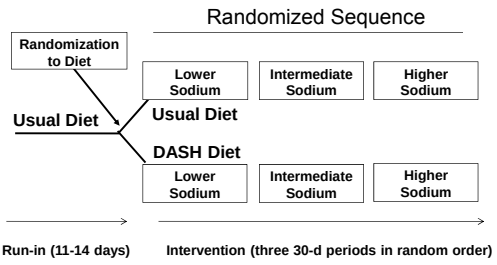


Blood Pressure Results (mmHg)

		Mean Change from Baseline in Each Diet		
Systolic BP	Baseline	CARB	PROT	UNSAT
All	131.2	-8.2	-9.5	-9.3
HTN Only	146.5	-12.9	-16.1	-15.8
PreHTN Only	127.5	-7.0	-8.0	-7.7
Diastolic BP	77.0	-4.1	-5.2	-4.8

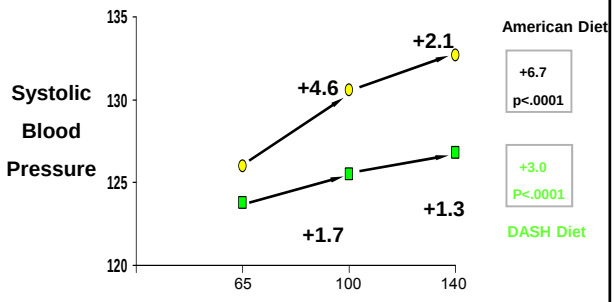
Appel et al. 2005

Mixed Study Design (DASH-Sodium)



Effect of Increased Sodium Intake on

Systolic Blood Pressure in Two Diets: Results of the DASH-Sodium Trial*



*Sacks et al, 2001

Approximate Daily Sodium Intake (mmol/day)

Factorial Design

- Type of trial in which individuals are randomized to two or more therapies (example: Physician's Health Study: tested aspirin (ASA) and β-carotene

	No β-carotene	β-carotene	
No ASA	Neither	β-carotene only	10,000
ASA	ASA only	Both	10,000
	10,000	10,000	20,000[18]

The African American Study of Kidney Disease and Hypertension (AASK)

AASK Research Questions

Among African-Americans with early evidence of hypertension-related kidney disease:

- Does aggressive blood pressure control to a target blood pressure below current recommendations retard the progression of kidney disease?
- Do specific classes of anti-hypertensive medications retard the progression of kidney disease?

Design of AASK

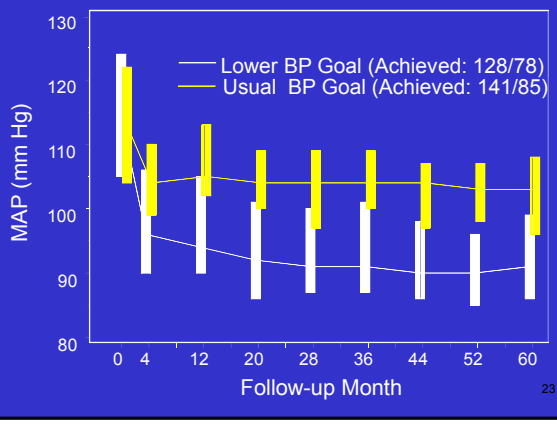
- Randomized, active controlled trial with a 2 x 3 factorial design
- Participants: 1,094 African-Americans with hypertension-related renal insufficiency
- Planned follow-up of 2.5 to 5 years

Treatment Assignments (2:2:1 ratio of drug assignment) 3 X 2 Factorial Design

	Metoprolol*	**Ramipril**	**Amlodipine**
MAP <92	20%	20%	10%
MAP 102-107	20%	20%	10%
N	441	436	217

MAP = Mean Arterial Pressure; * = referent group

Mean Arterial Pressure During Follow-up



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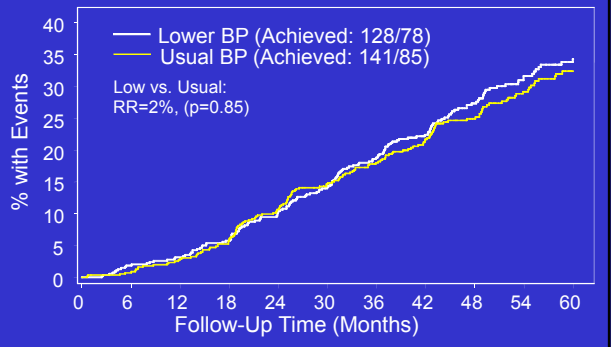
Composite Clinical Outcome

Declining GFR Event, ESRD or Death



RR=Risk Reduction, adjusted for baseline covariates

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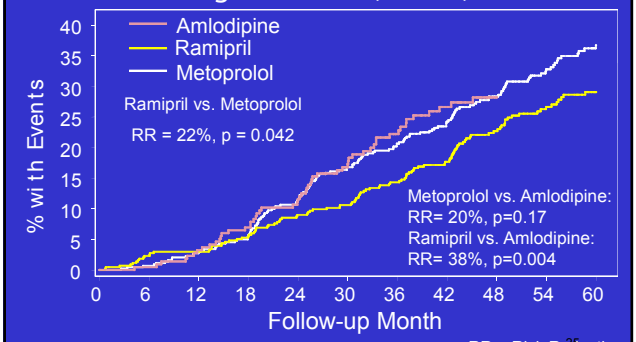
Main Clinical Composite Outcome

Declining GFR Event, ESRD, or Death



RR = Risk Reduction, Adjusting for Baseline Covariates

RR = Risk Reduction

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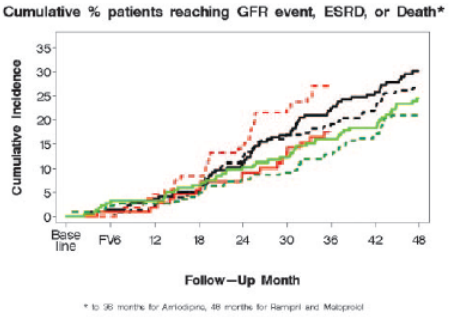
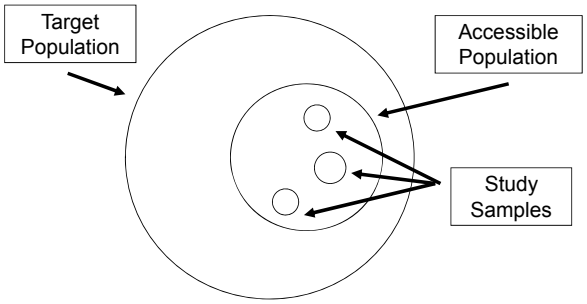


Study Participants



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Study Participants: Example

- Target Population -> Healthy Elderly
- Accessible Population -> Retired Teachers
- Study Sample -> Volunteer Teachers who respond to mass mailing

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Study Participants

- Ideal 'Accessible' Population
  - high risk for disease
  - candidates for treatment
  - representative of target population
  - feasibility considerations
    - recruitment
    - follow-up
    - high quality data

Enrollment Criteria

- Inclusion Criteria
  - characteristics of accessible population
- Exclusion Criteria
  - considerations related to:
    - adherence to therapy
    - follow-up
    - safety
    - ethics

Common Recruitment Strategies

- General mailings
  - Licensed drivers
  - Voters
  - Employee paychecks
- Targeted mailings
  - HMO enrollees
  - AARP members
- Mass media
  - Radio
  - TV ads
  - Newspapers
  - Posters/flyers
- Screenings
  - Worksite
  - Community
- Physician Referral
- Medical Record Review
- Internet / WWW
  - Clinical trial registries
  - Banner ads
  - Social networks

Comments on Recruitment

- Recruitment begins with design
- Response rate is always lower than expected
- Required resources are more than expected
- Dedicated personnel are necessary

More Comments on Recruitment

- Recruitment period is often longer than expected
- Implement several strategies to identify best source
- Prepare back-up strategies
- Monitor recruitment
  - Early
  - Often
  - Locally

Recruitment "Funnel" (Example: VITAL Pilot Study)

4,774 Mailed Invitations

↓ 43%

2,034 Questionnaires Returned

↓ 38%

765 Interested After Initial Mailing

↓ 41%

323 Randomizable after Second Mailing (7% cumulative)

↓

297 Randomized

Allocation

- Random
  - stratified
  - blocked
- Non-Random
  - haphazard
  - systematic

Why randomize?

- Two critical reasons:
  - to eliminate selection **BIAS**
  - to reduce/avoid **CONFOUNDING** from known and, more importantly, unknown confounders

Masking (Blinding)

- Single Blind
  - Observers (persons who collect outcome variable) do not know treatment assignment
- Double Blind
  - Study participants AND observers do not know treatment assignments
- Triple Blind
  - Data interpreters, study participants, and observers do not know treatment assignments

Masking (Blinding)

	Single Masked	Double Masked	Triple Masked
Outcome Assessor(s)	X	X	X
Participant		X	X
Data Interpreter			X

Selection of Groups

- Active Treatment Group
- Comparison Group
  - Placebo (no active therapy)
  - Usual care (referral back to personal MD)
  - Active control group (provision of standard therapy)

Problems with selecting active treatment group

- Many Candidate treatments
  - observation studies, animal models, or theoretically based
- Strong evidence rarely exists to guide selection of intervention
- Dose/intensity are uncertain

Comparison Group

- Placebo – used in setting of:
  - No standard therapy OR
  - Standard therapy but risk of not providing it is minimal
- Usual care OR active control – common

Problems with standard of care approach

- Efficacy of 'Usual care' often not tested
- Variations in standard of care are common:
  - across providers
  - between experts and providers
  - secular trends occur

Data

- Baseline data
  - Determine eligibility
  - Describe study participants
  - Define subgroups
  - Address confounding
- Measures of Adherence
- Outcome Variables

Outcome Variables

- Principal outcome
  - most important variable after randomization code
  - specified in hypothesis
  - determinant of sample size
- Secondary Outcomes
  - relevant to research question

Desirable Features of Outcome Variable

- clinically relevant
- easy to measure
- little measurement error
  - random error – leads to imprecision
  - systematic error – leads to bias
- masked (blinded) ascertainment

Surrogate Outcomes

- Definition: a laboratory measurement or physical sign used as a substitute for a clinically meaningful outcome
- Types: physiologic variable, clinical risk factor, or sub-clinical disease

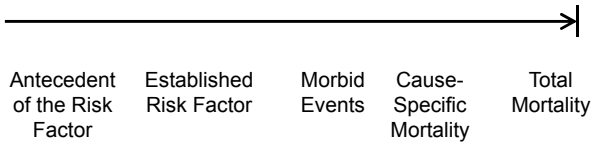
Advantages of Surrogate Outcomes

- Surrogate outcomes typically increase statistical power compared to clinical outcomes
  - Surrogate outcomes
    - often continuous
    - measured repeatedly
  - Clinical outcomes
    - often categorical
    - surveillance till outcome occurs

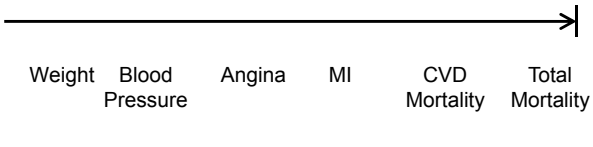
Advantages of Surrogate Outcomes (continued)

- Enhanced power means
  - shorter duration of follow-up and/or reduced sample size
  - less cost
- Less contamination by competing comorbidities if the study duration is short
- Useful in studies of mechanisms

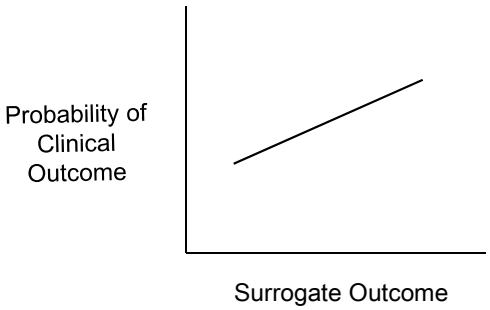
Surrogate and clinical outcomes: a continuum



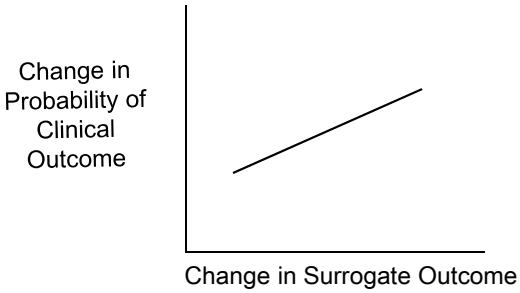
Surrogate and clinical outcomes: an example



Relationship between Surrogate and Clinical Outcomes

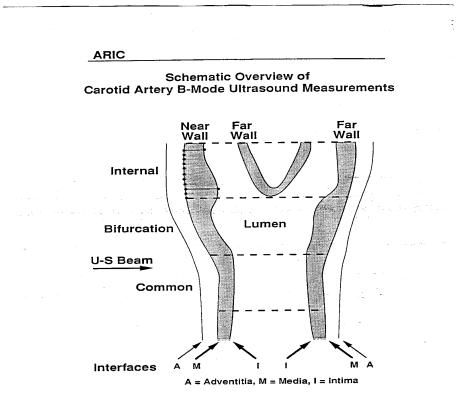


Relationship between Change in Surrogate Outcome and Change in Clinical Outcomes



Clinical and Surrogate Outcomes: Cardiovascular

Clinical	Surrogate
Stroke	Ultrasound measurement of intimal medial thickness of the carotid artery Blood pressure
Myocardial infarction	Quantitative coronary angiography Electron beam computerzied tomography
Sudden death	Ventricular arrhythmia
Heart failure	Ejection fraction



Weaknesses

Disadvantages of Surrogate Outcomes

- Measurement of surrogate outcomes can involve complex, technical procedures
  - procedures sometimes new (therefore, longitudinal data is scant)
  - procedures become obsolete
  - many technical and analytic issues, often unapparent

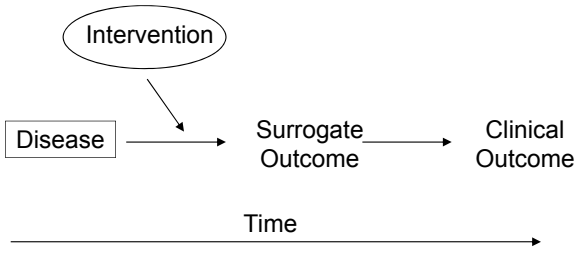
Disadvantages of Surrogate Outcomes (continued)

- Missing values are commonplace
- Missing values result from loss to follow-up and poor quality of data
- Potential for bias
  - missing values occur in the sickest people, sometimes because of the clinical outcome of interest
  - informative censoring, that is, loss of follow-up data potentially related to treatment assignment

Models for success and failure of surrogate outcomes*

*Fleming TR, DeMets DL. Surrogate End Points in Clinical Trials: Are we being mislead? Ann Int Med 1996;125:605-613.

Model for potential success: Surrogate outcome in the casual pathway



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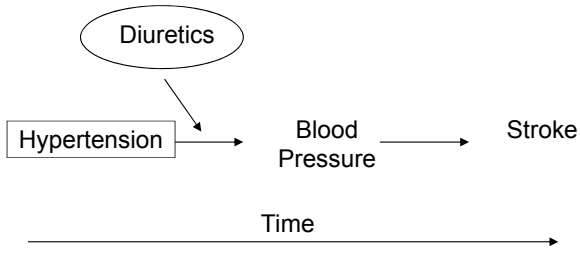
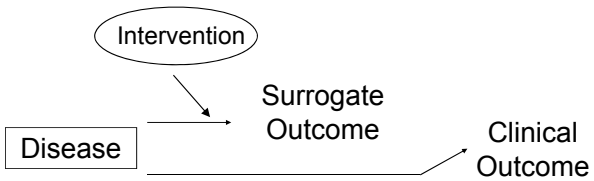


Model for failure: the surrogate is not in the causal pathway of the disease process



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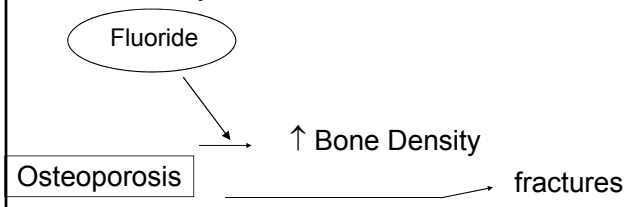
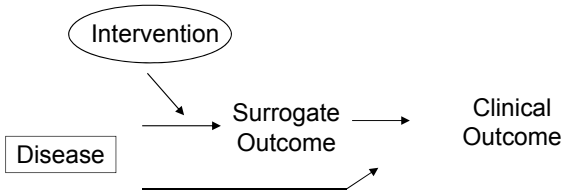


Model for failure: the intervention affects only the pathway mediated through the surrogate



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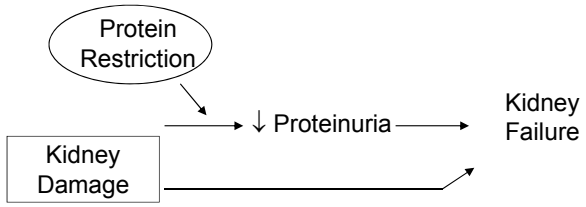
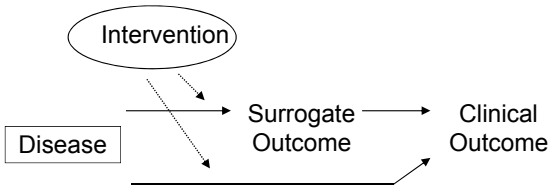
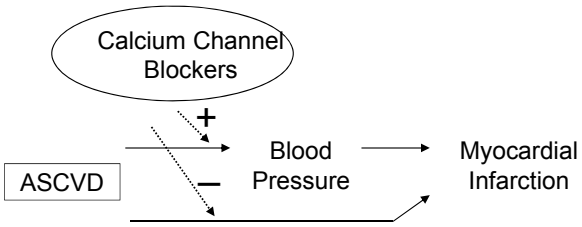


Model for failure: The intervention has several mechanisms of action



Example: Dihydropyridine calcium channel blockers



The Cardiac Arrhythmia Suppression Trial (CAST*): Background

- Ventricular arrhythmias are a risk factor for sudden death after MI
- Four fold higher risk of cardiac mortality among persons with frequent premature ventricular contractions (PVCs)
- In the CAST pilot study, the antiarrhythmic drugs (encainide, flecainide) suppressed PVCs

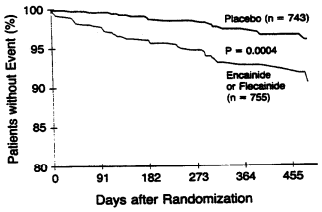
*Echt DS et al. Mortality and morbidity in patients receiving encainide, flecainide, or placebo. NEJM 1991: 324(12): 781-8.

CAST Research Question

Does suppression of ventricular ectopy after a MI reduce the incidence of sudden death?

CAST Design

- Design: randomized trials of
  - encainide vs placebo
  - flecainide vs placebo
- Participants (n=1498)
  - recent MI (6 days to 2 years ago)
  - ventricular ectopy (6 or more PVCs /hr)
  - at least 80% suppression of PVCs by active drug during open label titration period prior to randomization



Placebo	743	632	516	412	292	201
Active drug	755	631	507	392	286	198

Figure 1. Actuarial Probabilities of Freedom from Death or Cardiac Arrest Due to Arrhythmia in 1498 Patients Receiving Encainide or Flecainide or Corresponding Placebo.
The number of patients at risk of an event is shown along the bottom of the figure.

Source: Echt DS, Liebson PR, Mitchell B, et al. Mortality and morbidity in patients receiving encainide, flecainide, or placebo. The Cardiac Arrhythmia Suppression Trial. NEJM 1991: 324(12): 781-8.

CAST results: number of deaths and cardiac arrests by group

- Active treatment: 63 events / 755
- Placebo: 26 events / 743
  p = 0.0001

- same pattern of results for
  - death from arrhythmia
  - death from any cardiac cause
  - death from any cause

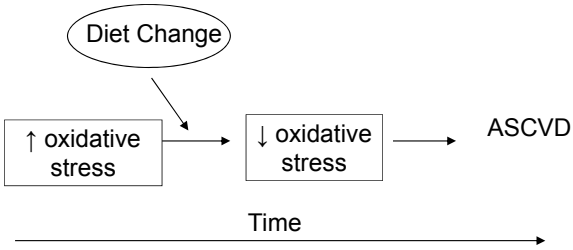
Lessons from CAST

- Active treatments can be harmful (one of several recent trials in which placebo was superior to active treatment)
- Reliance on surrogate outcomes can be misleading
- The scientific community should encourage researchers and sponsors to conduct studies with 'hard' clinical outcomes

Examples from the Field

- Surrogate that go in that go the right direction (easy to explain –fit your hypothesis)
- Surrogates that go in unexpected directions (create a greater need for hand-waving and but can still be made to fit your hypothesis)
- Surrogates that behave badly

Model for potential success: Surrogate outcome in the casual pathway



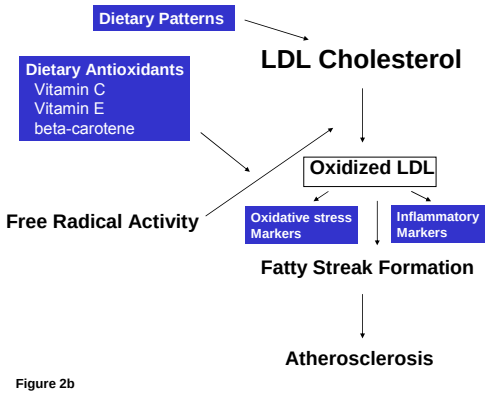


Figure 2b

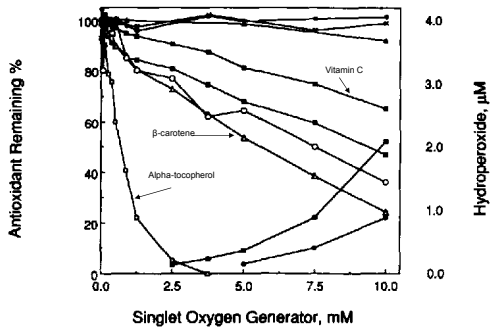


FIG. 1. Oxidation of plasma components (*left axis*; scale, 0–

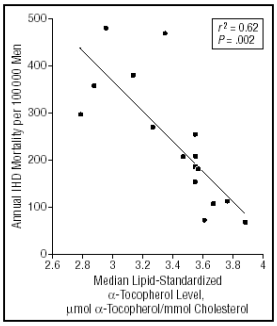


Figure 2. *Correlation between age-specific ischemic heart disease (IHD) mortality and median lipid-standardized α-tocopherol levels among men in 16 European countries.*[22]

Nurses Health Study

- Design: Prospective Cohort Study
- Participants: 121,700 female nurses free of diagnosed cardiovascular disease
- Exposure Assessment: Dietary questionnaire at baseline; Vitamin E and Multivitamin Use
- Follow-up: 8 years
- End Points: 1) Major Coronary Disease; 2) Non-fatal MI; 3) Deaths Due to Coronary Disease

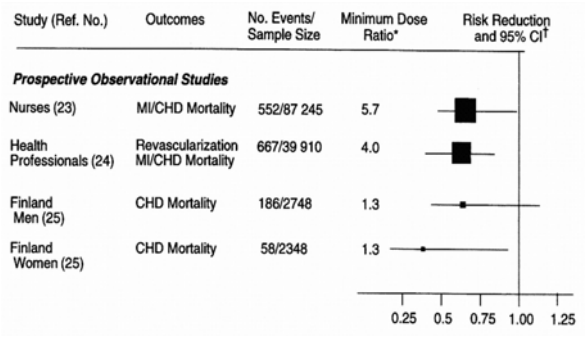
N Engl J Med 1993;328:1444-1449

Variable	Quintile Group for Vitamin E Intake					P Value for Trend
	1	2	3	4	5	
Total intake (including supplements)						
Median (IU/day)	2.8	4.2	5.9	17	208	—
Range (IU/day)	1.2–3.5	3.6–4.9	5.0–8.0	8.1–21.5	21.6–1000	—
Age-adjusted relative risk	1.0	0.90	1.00	0.68	0.59	—
95% Confidence interval	—	0.70–1.16	0.78–1.27	0.52–0.89	0.45–0.78	<0.001
Relative risk adjusted for age and smoking	1.0	1.00	1.15	0.74	0.66	—
95% Confidence interval	—	0.78–1.28	0.90–1.48	0.57–0.98	0.50–0.87	<0.001
Dietary intake (without supplements)						
Median (IU/day)	2.6	3.6	4.4	5.4	7.7	—
Range (IU/day)	0.3–3.1	3.2–3.9	4.0–4.8	4.9–6.2	6.3–100	—
Age-adjusted relative risk	1.0	0.97	0.77	0.98	0.79	—
95% Confidence interval	—	0.75–1.26	0.59–1.01	0.77–1.26	0.61–1.03	0.12
Relative risk adjusted for age and smoking	1.0	1.04	0.87	1.14	0.95	—
95% Confidence interval	—	0.80–1.35	0.66–1.14	0.89–1.47	0.72–1.23	0.99

*Major heart disease includes nonfatal myocardial infarction and death due to coronary disease.

N Engl J Med 1993;328:1444-1449

Prospective observational studies of vitamin E: Effects on cardiovascular end points



Adapted from: Jha, P. et. al. Ann Intern Med 1995;123:860-872

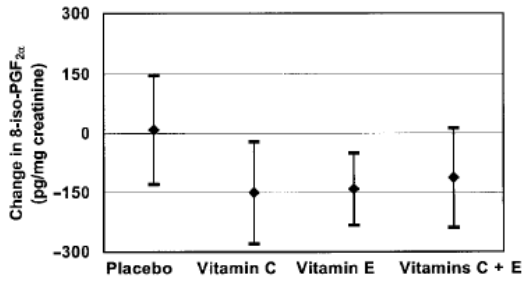


FIGURE 1. Mean changes (and 95% CIs) in urinary 8-iso-prostaglandin $F_{2\alpha}$ ($PGF_{2\alpha}$): 9.0 (−125.1, 143.1) in the placebo group, −150.0 (−275.4, −24.6) in the vitamin C group, −141.3 (−230.5, −52.1) in the vitamin E group, and −112.5 (−234.8, 9.8) in the vitamins C + E group. There was no synergistic interactive effect of vitamins C and E ($P = 0.12$).

Summary of Biological Evidence

- Antioxidants are necessary
- Oxidized lipids are associated with CVD
- Oxidation of lipids is reduced by antioxidant supplementation
- Does supplementation lower risk of CVD?
  - Observational studies
  - trials

Do Vitamin E supplements reduce risk?

- Observational studies are confounded –vitamin E takers exercise more, have a lower BMI, eat healthier diets and smoke less often that non-vitamin users
- Observational studies are hypothesis generating
- Surrogate markers are only indirectly related to clinical events
- Benefits can only be assessed in randomized controlled clinical trials

Clinical Trials – Clinical Outcomes

- Cardiovascular Events
  - Fatal and Non-fatal MI
  - Stroke
  - Peripheral artery disease
- Mortality

ATBC Study

- Design: Randomized, double-blind, placebo-controlled primary prevention trial
- Participants: 29,133 male Finnish smokers, age 50-69
- Intervention: 1) Vitamin E 50 IU/day
  2) B-carotene 20 mg/day
  3) Combination
  4) Placebo
- Follow-up: 5-8 years
- End Points: Incident lung cancer & deaths

ATBC, 1993 NEJM

Lancet 1997; **349:** 1715–20

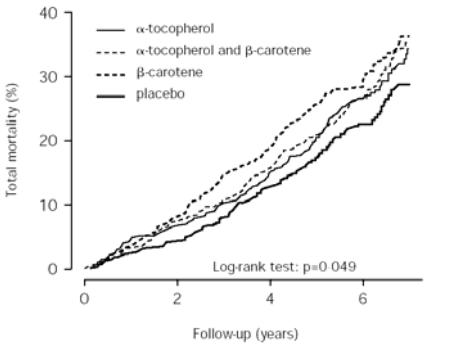


Figure 3: **Kaplan-Meier estimates of mortality**

ATBC Trial Results

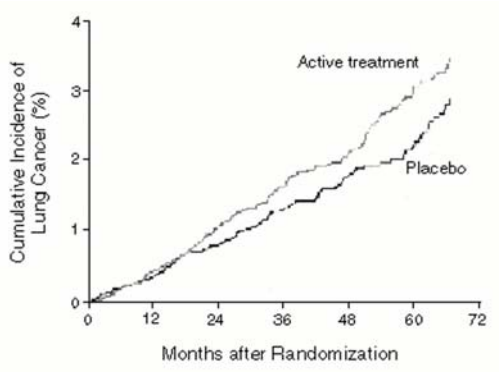
- Beta-carotene group (20 mg/day)
  - increase in total mortality (9%)
  - increased incidence of angina (13%)*
  - increased CVD mortality (11%)*
  - increased incidence of lung cancer (18%)
- Vitamin E Group (50 mg/day)
  - reduction in total coronary events (3%)
  - reduction in incident angina (9%)
  - reduction in non-fatal MI (11%)

ATBC, 1994 NEJM

CARET Study

- Design: Randomized, double blind, placebo-controlled primary prevention trial
- Participants: 18,314 smokers, former smokers, and workers exposed to asbestos
- Intervention: 1) B-carotene (30 mg/day) and vitamin A (25,000 IU/day)
  2) Placebo
- Follow-up: 4 years
- End Points: Incident lung cancer
  Cardiovascular Disease

Omenn, 1996 NEJM



Meta-Analysis: High-Dosage Vitamin E Supplementation May Increase All-Cause Mortality

Edgar R. Miller III, MD, PhD; Roberto Pastor-Barriuso, PhD; Darshan Dalal, MD, MPH; Rudolph A. Riemersma, PhD, FRCPE; Lawrence J. Appel, MD, MPH; and Eliseo Guallar, MD, DrPH

Background: Experimental models and observational studies suggest that vitamin E supplementation may prevent cardiovascular disease and cancer. However, several trials of high-dosage vitamin E supplementation showed non–statistically significant increases in total mortality.

Purpose: To perform a meta-analysis of the dose–response relationship between vitamin E supplementation and total mortality by using data from randomized, controlled trials.

Patients: 135 967 participants in 19 clinical trials. Of these trials, 9 tested vitamin E alone and 10 tested vitamin E combined with other vitamins or minerals. The dosages of vitamin E ranged from 16.5 to 2000 IU/d (median, 400 IU/d).

Data Sources: PubMed search from 1966 through August 2004, complemented by a search of the Cochrane Clinical Trials Database and review of citations of published reviews and meta-analyses. No language restrictions were applied.

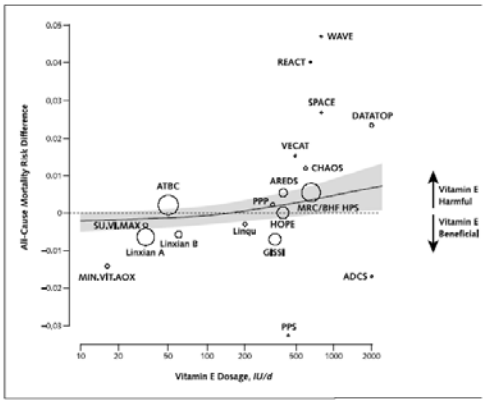
Data Extraction: 3 investigators independently abstracted study reports. The investigators of the original publications were contacted if required information was not available.

Data Synthesis: 9 of 11 trials testing high-dosage vitamin E (≥400 IU/d) showed increased risk (risk difference > 0) for all-cause mortality in comparisons of vitamin E versus control. The pooled all-cause mortality risk difference in high-dosage vitamin E trials was 39 per 10 000 persons (95% CI, 3 to 74 per 10 000 persons; $P = 0.035$). For low-dosage vitamin E trials, the risk difference was −16 per 10 000 persons (CI, −41 to 10 per 10 000 persons; $P > 0.2$). A dose–response analysis showed a statistically significant relationship between vitamin E dosage and all-cause mortality, with increased risk of dosages greater than 150 IU/d.

Limitations: High-dosage (≥400 IU/d) trials were often small and were performed in patients with chronic diseases. The generalizability of the findings to healthy adults is uncertain. Precise estimation of the threshold at which risk increases is difficult.

Conclusion: High-dosage (≥400 IU/d) vitamin E supplements may increase all-cause mortality and should be avoided.

Ann Intern Med. 2005;142:37-46. www.annals.org
For author affiliations, see end of text.



Failed surrogate marker: example

β- carotene supplements

\+ ↑β-carotene

Smoking
↓β-carotene

− ↑Lung Cancer

Need for reliable surrogate markers

Disadvantages of Surrogate Outcomes (continued)

- The relationship between a surrogate outcome and a clinical outcome has face validity but is often uncertain
- Relationship between change in surrogate and risk of clinical outcomes is rarely known

The Bottom Line

"Trust but verify"

Ronald Reagan

Analytical Issues

- Sample Size (Power Calculations)
- Analytical Approach (a priori)
- Intention-to-treat (vs 'as treated')

Analytic Techniques: Crude analyses

- Analysis depends on the type of outcome data
- Basic tests
  - Continuous outcome variable: **t-test**
    - Examples: Blood pressure, serum cholesterol
  - Dichotomous or categorical data: **chi-squared, logistic regression, cox modeling for time to event**
    - Example: Incident HIV, MI, cancer, renal failure, death

Epidemiology in a box: The 2x2 table

- The EXPOSURE (E)
  - Example: obesity
- The OUTCOME (D)
  - Example: Hypertension
- Applicable to most study designs

	D+	D-	
E+	a	b	a+b
E-	c	d	c+d
	a+c	b+d	Total

Analytic Techniques: Adjusted (Regression) Analyses

- Regression determines association between exposure and outcome
- Procedures depends on outcome variable:
  - Continuous outcome: **linear regression**
  - Dichotomous outcome: **logistic regression**
  - Time-to-event: **Cox proportional hazards**

Interpretation of Results

- Internal Validity
  - conclusions correctly describe what happened in the study
- External Validity ('generalizability')
  - the degree to which the conclusions apply to the study population and other populations

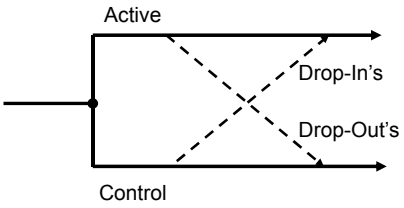
Why RCTs Can Be Difficult

- Hard to find and recruit the right people
  - Many don't want to be "guinea pigs"
- Greater responsibility, documentation
- May take years for outcomes to develop
- People are free to do as they please
  - Some assigned to treatment don't adhere
  - Some assigned to control seek treatment
  - Some drop out of the trial completely

Adherence (compliance)

- Difficult to measure
- Difficult to promote
- Must be promoted and measured, at least in efficacy or explanatory trials

Why be worried about adherence?



Intention-to-Treat: analysis by randomized group, not by final groupings

Adherence (compliance)

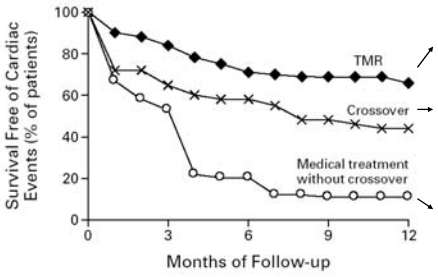
- Measurement
  - self report
  - pill count
  - blood levels of drug
  - biological changes (urine or blood)
- Promotion
  - exclude poor candidates before randomization
  - keep intervention simple
  - respond to evidence of inadequate adherence

How To Handle Participants Who Don't Adhere to Trial Assignment

- Intention-to-Treat Approach
  - Least optimistic
  - Maintains initial balance from randomization
  - Highlights problems from adverse effects
- On-Treatment Approach
  - Most optimistic
  - Upsets initial balance from randomization
  - Downplays problems from adverse effects

Because of its conservatism, the Intention-to-Treat approach is strongly preferred.

Cardiac Event-Free Survival in 192 Adults with Refractory Angina by Random Assignment and Cross-Over (from Medical Treatment to TMR) Status



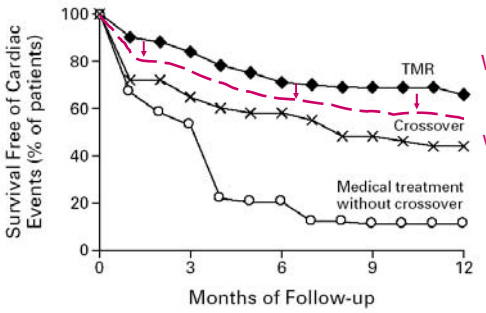
Randomized to TMR, no crossing over to Medical Rx

Randomized to Medical Rx, did poorly, needed TMR as last ditch effort

Randomized to Medical Rx, did OK, no need for TMR

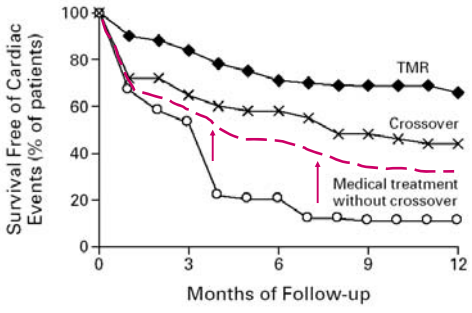
TMR =transmyocardial laser revascularization

Cardiac Event-Free Survival in 192 Adults with Refractory Angina by Random Assignment and Cross-Over (from Medical Treatment to TMR) Status



Were X-overs reclassified as "TMR", it would tend to make TMR look worse

Cardiac Event-Free Survival in 192 Adults with Refractory Angina by Random Assignment and Cross-Over (from Medical Treatment to TMR) Status



Were X-overs classified as "Medical Rx", it would tend to make Medical Rx look better

Clinical Trials: Design and interpretation Considerations

When Trials Are Impossible (or Nearly Impossible)

- Adverse Exposures (e.g. Cigarettes)
- Rare Outcomes (e.g. Reye's Syndrome)
- Intervention Already in Wide Use

In these circumstances, one must rely on observational studies—i.e. prospective cohort studies and case-control studies. When interventions are already in wide use, "outcomes research" is a good option. In outcomes research, medical interventions (e.g. drugs, surgical procedures) are considered as exposures. Data on these interventions, and on relevant clinical outcomes, are available from medical records and often from large-scale electronic databases.

Statistical vs Clinical Significance

- Statistical significance pertains to whether or not the observed results could occur from chance alone
- Clinical significance pertains to whether or not the observed results have "important" clinical, research or public health relevance.

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How To Interpret Negative Results

- Treatment is worthless
- Treatment is worthwhile, BUT study had…
  - Bias against the treatment (e.g. crossing in)
  - Inadequate contrast between groups
    - Suboptimal treatment (e.g. unskilled surgeons)
    - Low adherence (e.g. drug causes GI distress)
    - Controls sought treatment despite assignment
  - Insufficient statistical power
    - Very common cause of negative findings
    - Meta-analysis a potential remedy

Efficacy (Explanatory) Trial vs Effectiveness (Pragmatic) Trial

- Theory
  - Efficacy: What is the effect of the therapy under ideal conditions
  - Effectiveness: What is the effect of therapy under 'real world' conditions
- Reality
  - The dichotomy between efficacy and effectiveness is artificial
  - Broad continuum

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Typical Implementation Units

- Clinical Centers
  - recruit participants
  - collect data
  - administer intervention/therapy
- Laboratory or Reading Centers
  - perform assays or readings of procedures
- Data Coordinating Center*
  - receive/assemble data
  - coordinate activities
  - perform data analyses

* similar to Contract Research Organization (CRO)

Oversight Units

- Internal
  - Sponsor
  - Data Coordinating Center or Contract Research Organization
- External
  - Institutional Review Board
  - Data and Safety Monitoring Board

Organizational Structure of a Multi-Center Trial (Weight Loss Maintenance Trial)