

Creating policy-relevant evidence for population health science: promise and pitfalls

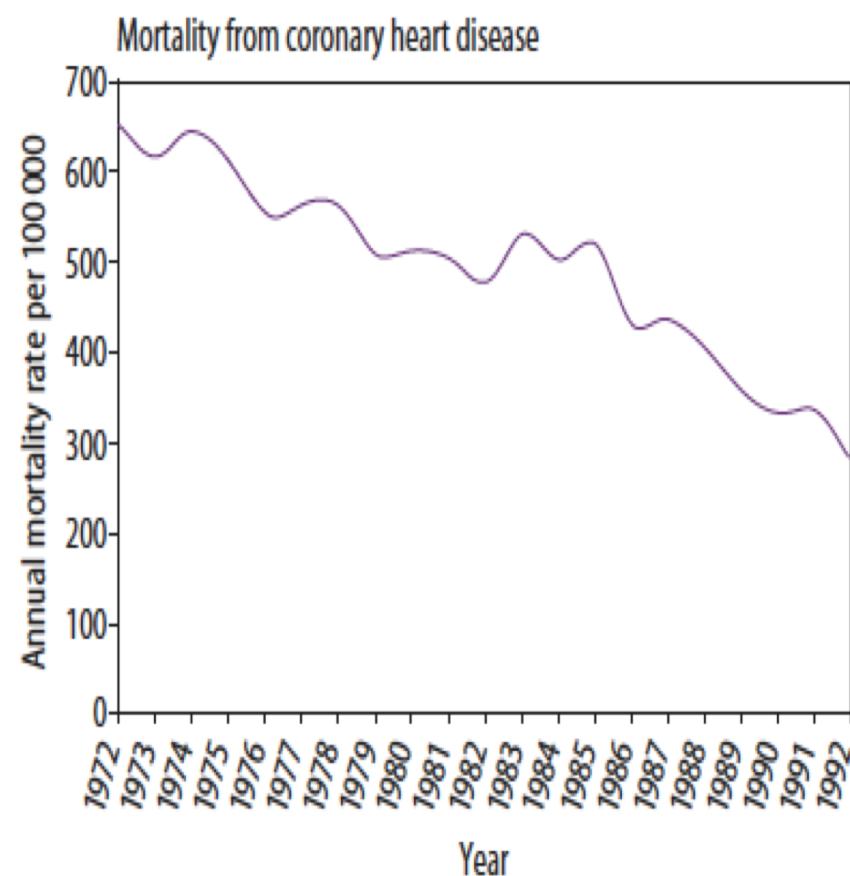
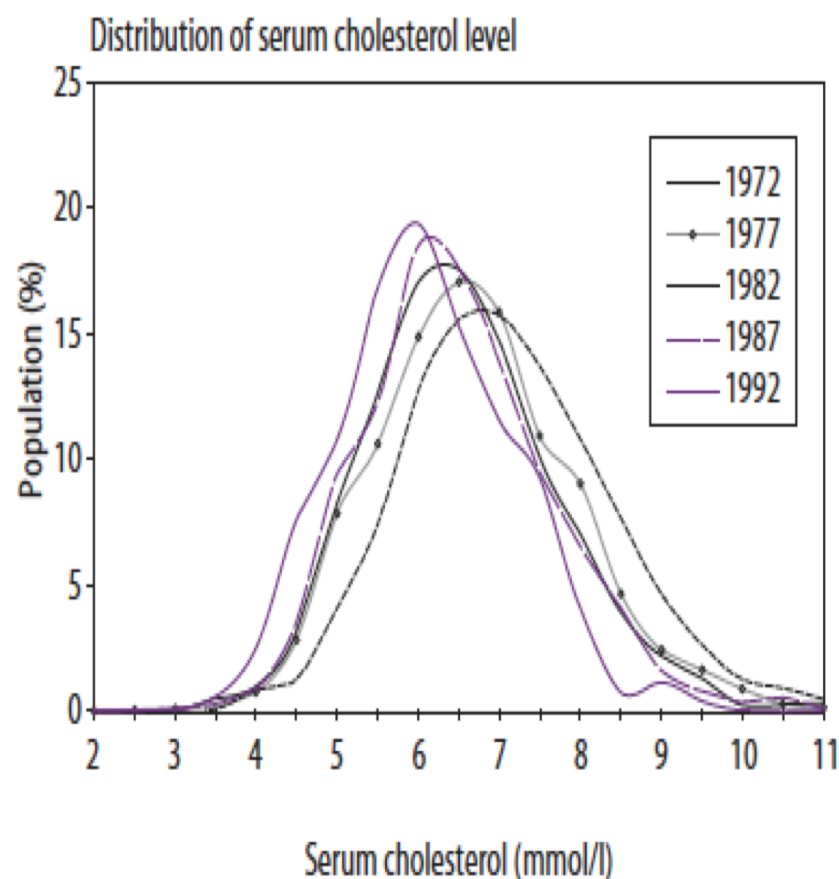
Sandro Galea

Boston University School of Public Health



It all started here

Cholesterol distributions and coronary heart disease rates, men 30–59 years of age, North Karelia, Finland, 1972–1992



Emerging experiments in population health



Press Releases

Boston Medical Center to Invest \$6.5 Million in Affordable Housing to Improve Community Health and Patient Outcomes, Reduce Medical Costs

December 07, 2017

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Boston Medical Center to Invest \$6.5 Million in Affordable Housing to Improve Community Health and Patient Outcomes, Reduce Medical Costs

BMC's investment, the first in Boston, joins a growing national trend of hospitals prescribing housing for health

(Boston) – Dec. 7, 2017 – Boston Medical Center is investing \$6.5 million over five years to support a wide range of affordable housing initiatives, in an innovation lab approach that will be studied closely to determine the best ways that health care systems can improve both community and patient level health and reduce medical costs by addressing homelessness and housing

We do have some evidence

Office of the Associate Director for Policy

[AD for Policy Home](#)

Health System Transformation

6|18 Initiative

Health Impact in 5 Years

The HI-5 Interventions

HI-5 14 Evidence-Based Community-Wide Interventions Slides

HI-5 Stories from Public Health Innovators

School-Based Programs to Increase Physical Activity

School-Based Violence Prevention

Safe Routes to School (SRTS)

Motorcycle Injury Prevention

Tobacco Control Interventions

Access to Clean Syringes

Pricing Strategies for Alcohol Products

Multi-component Worksite Obesity Prevention

Early Childhood Education

Clean Diesel Bus Fleets

Public Transportation System Introduction or

[AD for Policy Home](#) > [Health System Transformation](#) > [Health Impact in 5 Years](#)

The HI-5 Interventions



What are the HI-5 Interventions?



Interventions Changing the Context

- [School-Based Programs to Increase Physical Activity](#)
- [School-Based Violence Prevention](#)
- [Safe Routes to School](#)
- [Motorcycle Injury Prevention](#)
- [Tobacco Control Interventions](#)
- [Access to Clean Syringes](#)
- [Pricing Strategies for Alcohol Products](#)
- [Multi-Component Worksite Obesity Prevention](#)

Interventions Addressing the Social Determinants of Health

- [Early Childhood Education](#)
- [Clean Diesel Bus Fleets](#)
- [Public Transportation: System Introduction or Expansion](#)
- [Home Improvement Loans and Grants](#)
- [Earned Income Tax Credits](#)
- [Water Fluoridation](#)



Financial support for habitable homes: After rehabilitating housing 62% of adults have excellent health vs 33% before

<https://www.cdc.gov/policy/hst/hi5/homeimprovement/index.html> ; Breysse J et al. Health Outcomes and Green Renovation of Affordable Housing. [Public Health Rep.](#) 2011; 126(Suppl 1): 64-75. doi: [10.1177/003335491112605110](https://doi.org/10.1177/003335491112605110)
https://www.flickr.com/photos/nodding_pig/15588502703/sizes/l



**In a city of a million residents, 40 percent expansion
of transit developments has annual health benefit of
\$216 million**

<https://www.cdc.gov/policy/hst/hi5/publictransportation/index.html>
Institute <http://www.apta.com/resources/reportsandpublications>

Source: <http://www.apta.com/resources/reportsandpublications> - *Estimating the Economic and Health Benefits*. 2010, Victoria Transport Policy Institute <http://www.apta.com/resources/reportsandpublications>



Early childhood education associated with benefit:cost ratio of \$5:\$1 with reduction in crime rate, child maltreatment, teen pregnancy, academic achievement

<https://www.cdc.gov/policy/hst/hi5/earlychildhoodeducation/index.html>

The Guide to Community Preventive Services, *Promoting Health Equity Through Education Programs and Policies: Center-Based Early Childhood Education*. The Community Guide: What Works to Promote Health 2015 October 27, 2015 [cited 2015 November 30]; Available from: [Promoting Health Equity Through Education Programs and Policies: Center-Based Early Childhood Education](#).

Halfon, N. and M. Hochstein, *Life course health development: an integrated framework for developing health, policy, and research*. Milbank Quarterly, 2002. **80**(3): p. 433-479.

Isaacs, J.B., *Cost Effective Investments in Children* Isaacs. 2007, The Brookings Institute: Washington D.C.

A photograph of a woman with dark hair pulled back, looking directly at the camera with a serious expression. She is holding a young child with dark, curly hair who is looking slightly to the side. They are positioned in front of a weathered wooden wall. The lighting is soft and natural.

**Each time the Earned Income Tax Credit increases
by 10 percent, infant mortality drops by 23.2 per
100,000**

<https://www.cdc.gov/policy/hst/hi5/taxcredits/index.html>

Arno, P.S., et al., *Bringing health and social policy together: The case of the earned income tax credit*. *Journal of public health policy*, 2009. 30(2): p. 198-207.

LEVERAGING THE SOCIAL DETERMINANTS OF HEALTH: WHAT WORKS?

Executive Summary

JUNE 2015

Challenges in producing evidence

1. External validity

Let us suppose we want to know:

Does a particular intervention result in normotension?

Sample 1 from Population 1:

	Diseased	Not Diseased
Exposed	 50	 50
Unexposed	 200	 200

$$\text{Risk difference} = \frac{50}{100} - \frac{200}{400} = 0.5 - 0.5 = 0 \text{ (95\% CI - 0.109, 0.109)}$$

Sample 1 from Population 1:

	Diseased	Not Diseased
Exposed	 50	 50
Unexposed	 200	 200

No association

$$\text{Risk difference} = \frac{50}{100} - \frac{200}{400} = 0.5 - 0.5 = 0 \text{ (95\% CI } -0.109, 0.109)$$

Sample 2 from Population 2:

	Diseased	Not Diseased
Exposed	 100	 100
Unexposed	 50	 250

$$\text{Risk difference} = \frac{100}{200} - \frac{50}{300} = 0.5 - 0.166 = 0.333 \text{ (95\% CI 0.252, 0.414)}$$

Sample 2 from Population 2:

	Diseased	Not Diseased
Exposed	 100	 100
Unexposed	 50	 100

33 additional cases of normotension for every 100 cases with the intervention

$$\text{Risk difference} = \frac{100}{200} - \frac{50}{300} = 0.5 - 0.166 = 0.333 \text{ (95\% CI 0.252, 0.414)}$$

Sample 3 from Population 3:

	Diseased	Not Diseased
Exposed	 40	 110
Unexposed	 60	 290

$$\text{Risk difference} = \frac{40}{150} - \frac{60}{350} = 0.266 - 0.171 = 0.095 \text{ (95\% CI 0.014, 0.176)}$$

Sample 3 from Population 3:

	Diseased	Not Diseased
Exposed	 40	 110
Unexposed	 60	10 additional cases of normotension for every 100 cases with the intervention

Risk difference = $\frac{40}{150} - \frac{60}{350} = 0.266 - 0.171 = 0.095$ (95% CI 0.014, 0.176)

Why?

The intervention alone does not cause normotension; the intervention needs to happen together with exposure to other conditions

What the causal structure may look like if X, the intervention, and Y, social condition are both necessary and insufficient causes of disease

Component Causes	
X	Y
✓	✓
✓	
	✓

What the causal structure may look like if X, the intervention, and Y, social condition are both necessary and insufficient causes of disease

Component Causes		Probability of disease
X	Y	
✓	✓	1
✓		0
	✓	0
		0

Sample 1 from Population 1:

	Diseased	Not Diseased
Exposed	 50	 50
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0% social
condition

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	Diseased	Not Diseased
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$$\text{Risk difference} = \frac{50}{100} - \frac{200}{400} = 0.5 - 0.5 = 0 \text{ (95\% CI } -0.109, 0.109\text{)}$$

50% social
condition

Sample 2 from Population 2:

	Diseased	Not Diseased
Exposed	 100	 100
Unexposed	 50	 250

$$\text{Risk difference} = \frac{100}{200} - \frac{50}{300} = 0.5 - 0.166 = 0.333 \text{ (95\% CI } 0.252, 0.414\text{)}$$

40% social
condition

Sample 3 from Population 3:

	Diseased	Not Diseased
Exposed	 40	 110
Unexposed	 60	 290

$$\text{Risk difference} = \frac{40}{150} - \frac{60}{350} = 0.266 - 0.171 = 0.095 \text{ (95\% CI } 0.014, 0.176\text{)}$$

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50% social condition

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40% social condition

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No one here will develop normotension due to the intervention because the causal partner is not present; hence equal likelihood of normotension among those exposed/unexposed to the intervention

Component Causes		Probability of disease
X	Y	
✓	✓	1
✓		0
	✓	0
		0

Sample 2 from Population 2:

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$$\text{Risk difference} = \frac{40}{150} - \frac{60}{350} = 0.266 - 0.171 = 0.095 \text{ (95\% CI 0.014, 0.176)}$$

50% of those who are exposed to the intervention are exposed to the social condition, hence have normotension

40% of those who are exposed to the intervention are exposed to the social condition, hence have normotension

Sample 2 from Population 2:

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$$\text{Risk difference} = \frac{40}{150} - \frac{60}{350} = 0.266 - 0.171 = 0.095 \text{ (95\% CI 0.014, 0.176)}$$

17% of those who are
unexposed to the
intervention have
normotension

17% of those who are
unexposed to the
intervention have
normotension

Sample 2 from Population 2:

	Diseased	Not Diseased
Exposed	 100	 100
Unexposed	 50	 250

$$\text{Risk difference} = \frac{100}{200} - \frac{50}{300} = 0.5 - 0.166 = 0.333 \text{ (95\% CI 0.252, 0.414)}$$

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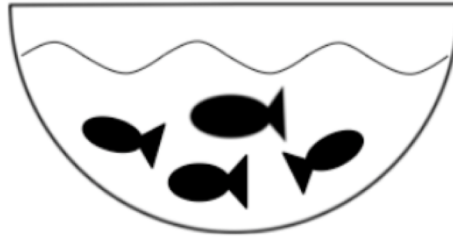
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Exposed	 40	 110
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$$\text{Risk difference} = \frac{40}{150} - \frac{60}{350} = 0.266 - 0.171 = 0.095 \text{ (95\% CI 0.014, 0.176)}$$

Therefore under a very plausible assumption of co-occurring causes, the medical intervention-health association can only be understood if we understand the *other* factors that distinguish between samples

2. Ubiquity

Figure 1. A metaphor for ubiquity



The goldfish are surrounded by water and everything they do is influenced by the quality of the water in which they live; therefore, water is a ubiquitous factor influencing the fish and needs to be taken into consideration every time we may want to improve the lives of the fish.

Crack Babies: The Worst Threat Is Mom Herself

By Douglas J. Besharov

LAST WEEK in this city, Greater Southeast Community Hospital released a 7-week-old baby to her homeless, drug-addicted mother even though the child was at severe risk of pulmonary arrest. The hospital's explanation: "Because [the mother] demanded that the baby be released."

The hospital provided the mother with an apnea monitor to warn her if the baby stopped breathing while asleep, and trained her in CPR. But on the very first night, the mother went out drinking and left the child at a friend's house—without the monitor. Within seven hours, the baby was dead. Like Dooney Waters, the 6-year-old living in his mother's drug den, whose shocking story was reported in The Washington Post last week, this child was all but abandoned by his mother.

September 17, 1989

Crack's Toll Among Babies: A Joyless View

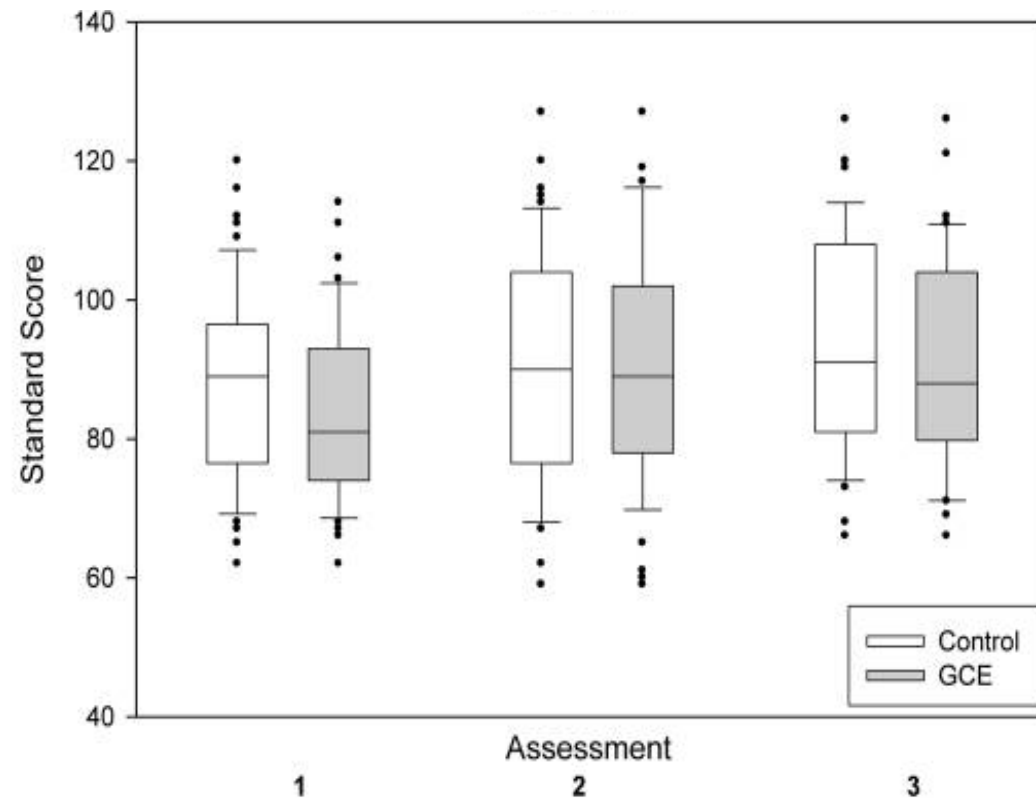
September 6, 1988

Cocaine: Litany of Fetal Risks Grows



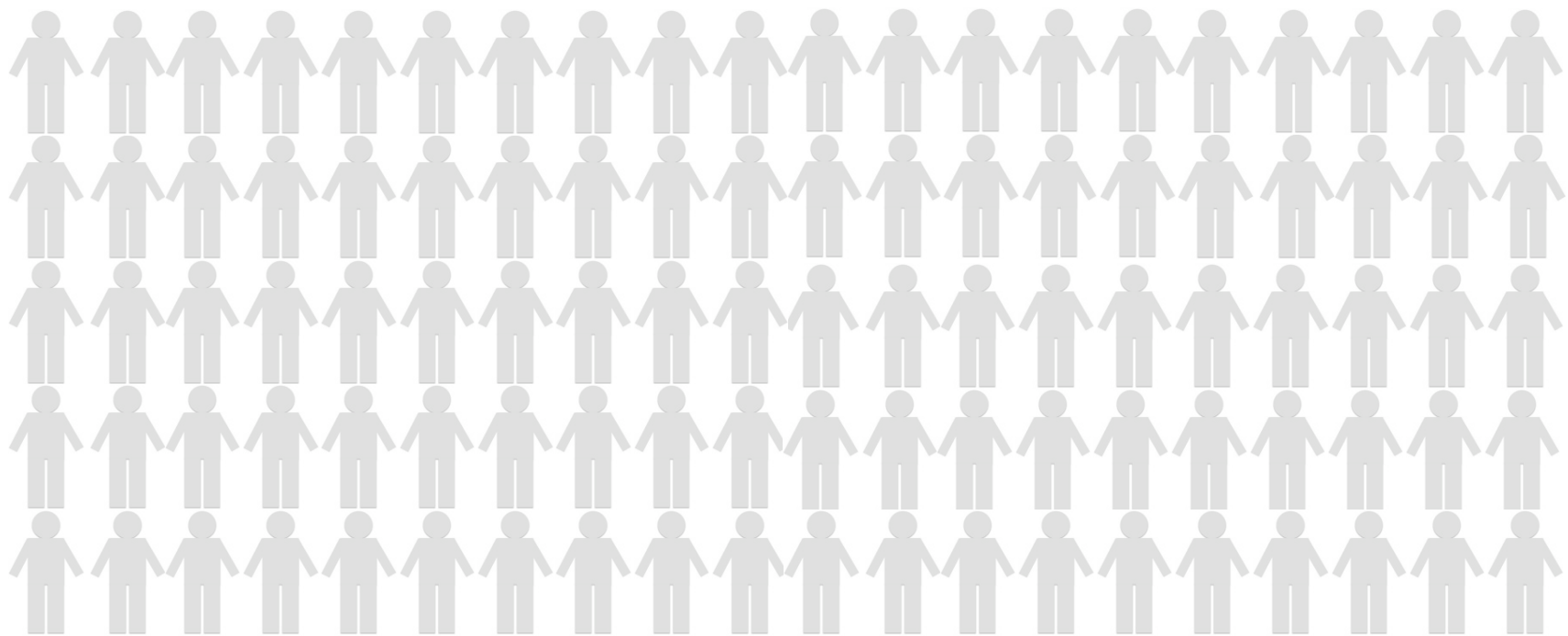
CHILDREN OF COCAINE (By Charles Krauthammer)

Peabody Picture Vocabulary Test



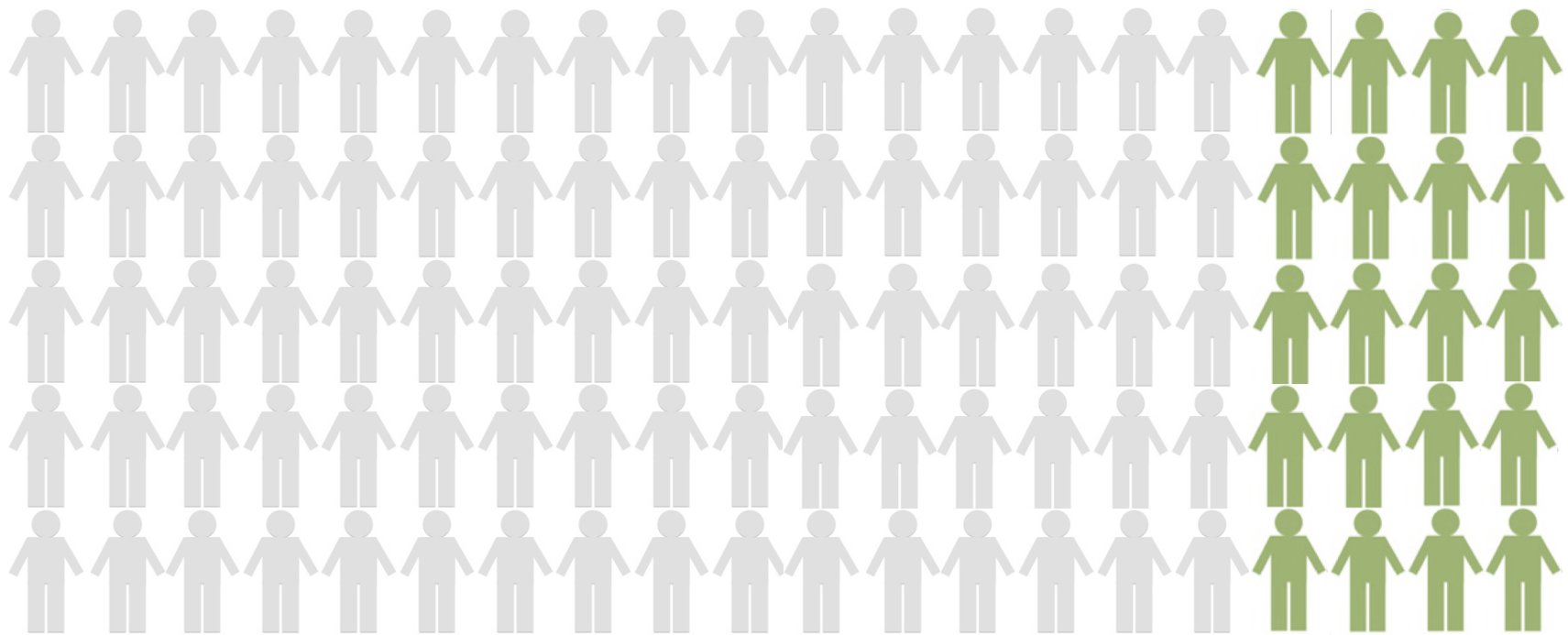
Predictor for Peabody Picture Vocabulary Test score	Coefficient	P-value
Gestational cocaine exposure	-2.89	0.26
Assessment no.	2.72	<0.001
Gestational cocaine exposure x assessment no.	0.58	0.51
Age at 1st assessment	-0.36	0.76
Female gender	-4.93	0.058
Parental nurturance	-0.31	0.89
Environmental stimulation	5.91	0.039
Caregiver BDI-II depression score	0.03	0.84

How much of our cognitive ability is determined by our genes?





 = GE+



 = ENV+



 = CA+

Scenario 1



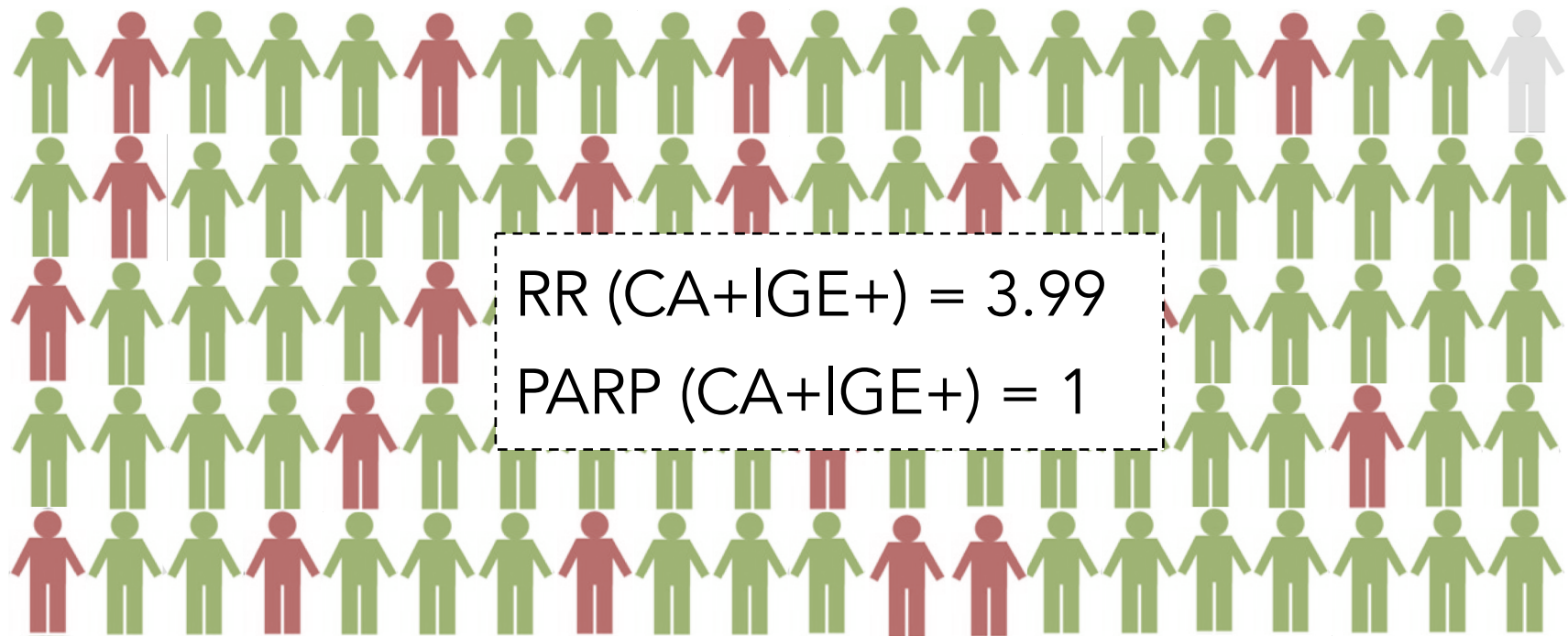
 = GE+  = CA+  = ENV+

Scenario 1



 = GE+  = CA+  = ENV+

Scenario 1



 = GE+  = CA+  = ENV+

Scenario 2



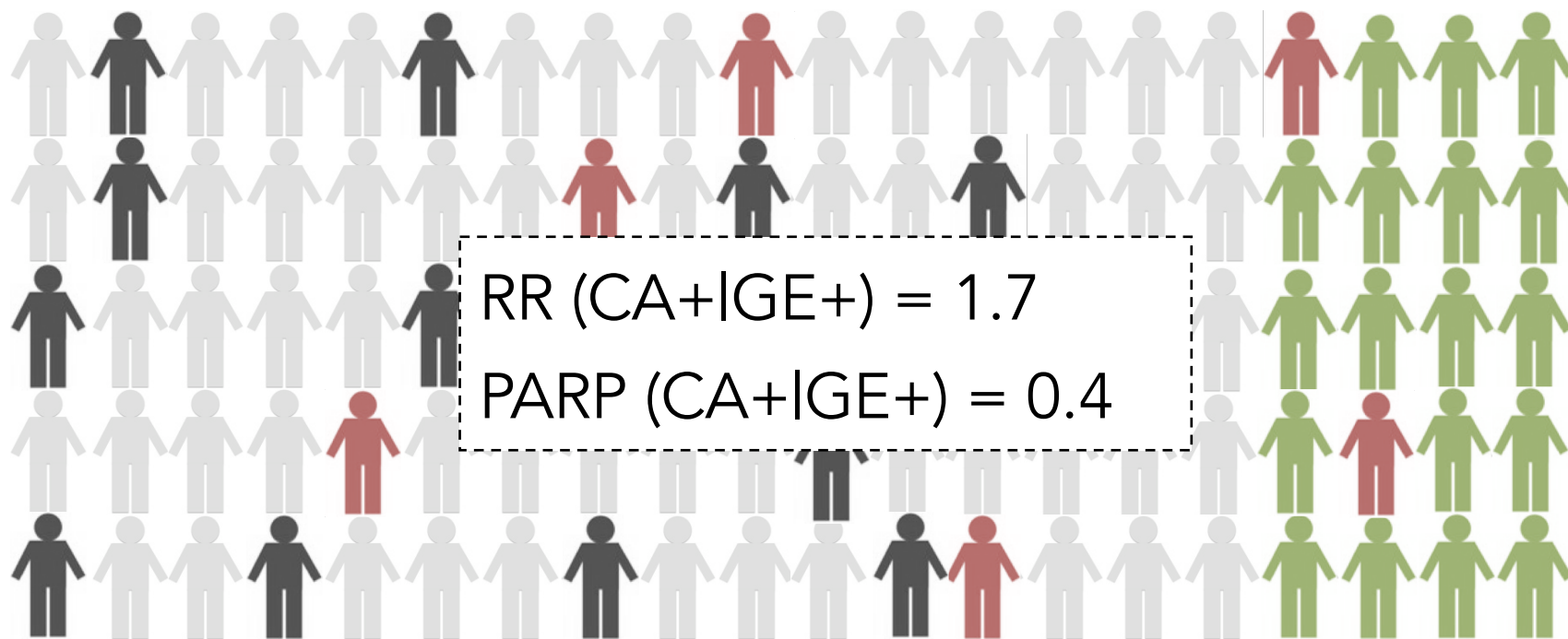
 = GE+  = CA+  = ENV+

Scenario 2



 = GE+  = CA+  = ENV+

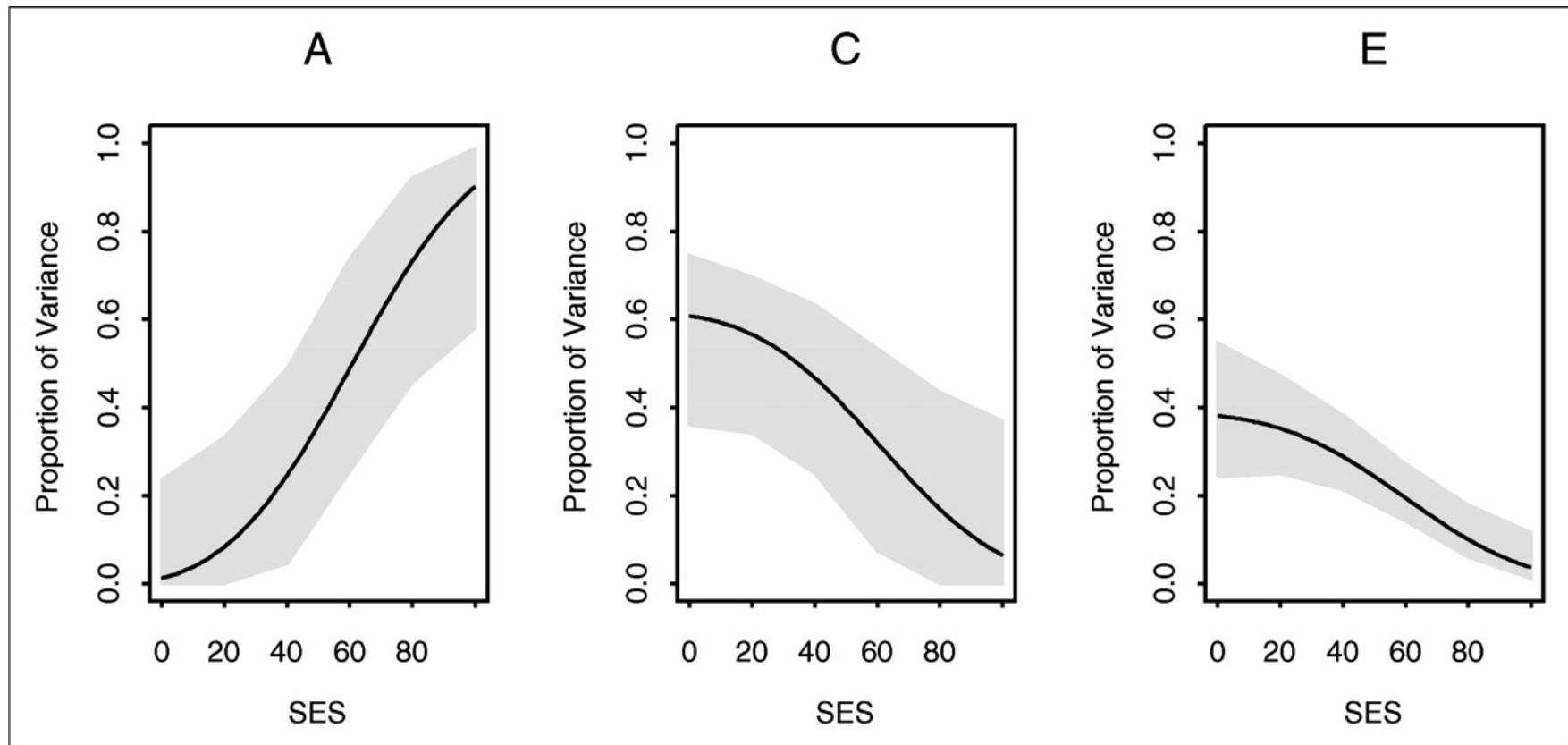
Scenario 2



 = GE+  = CA+  = ENV+

Is this all theoretical?

Proportion of total Full-Scale IQ variance accounted for by A, C, and E plotted as a function of observed socioeconomic status (SES).



3. We cannot think in dichotomies

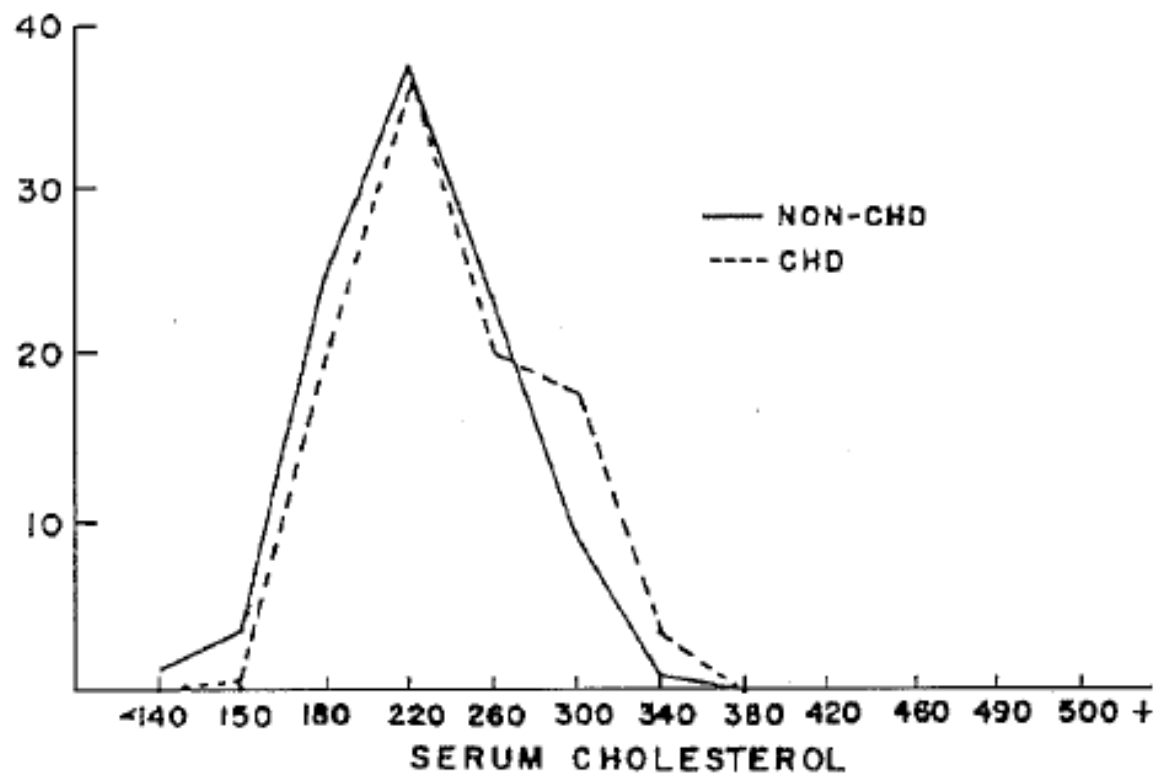


Figure 3 Percentage distribution of serum cholesterol levels (mg/dl) in men aged 50-62 who did or did not subsequently develop coronary heart disease (Framingham Study⁵)

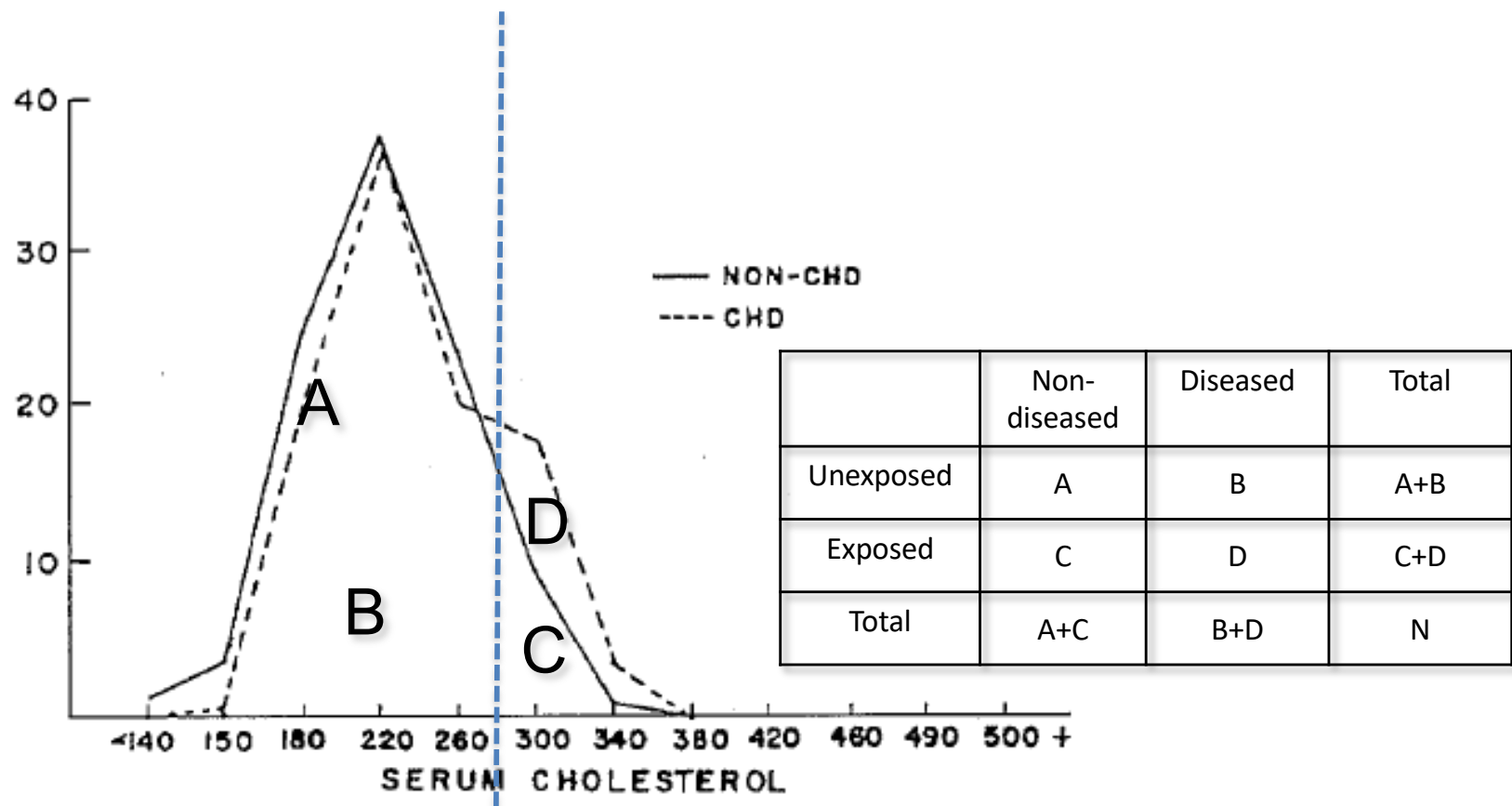


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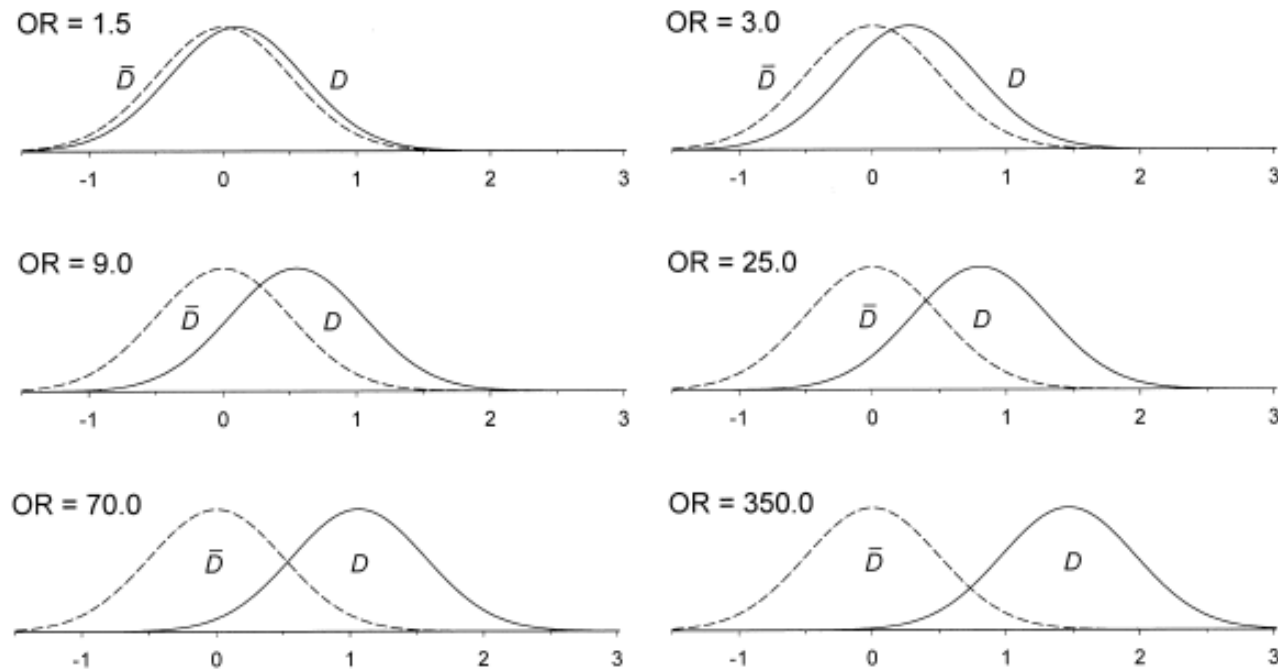
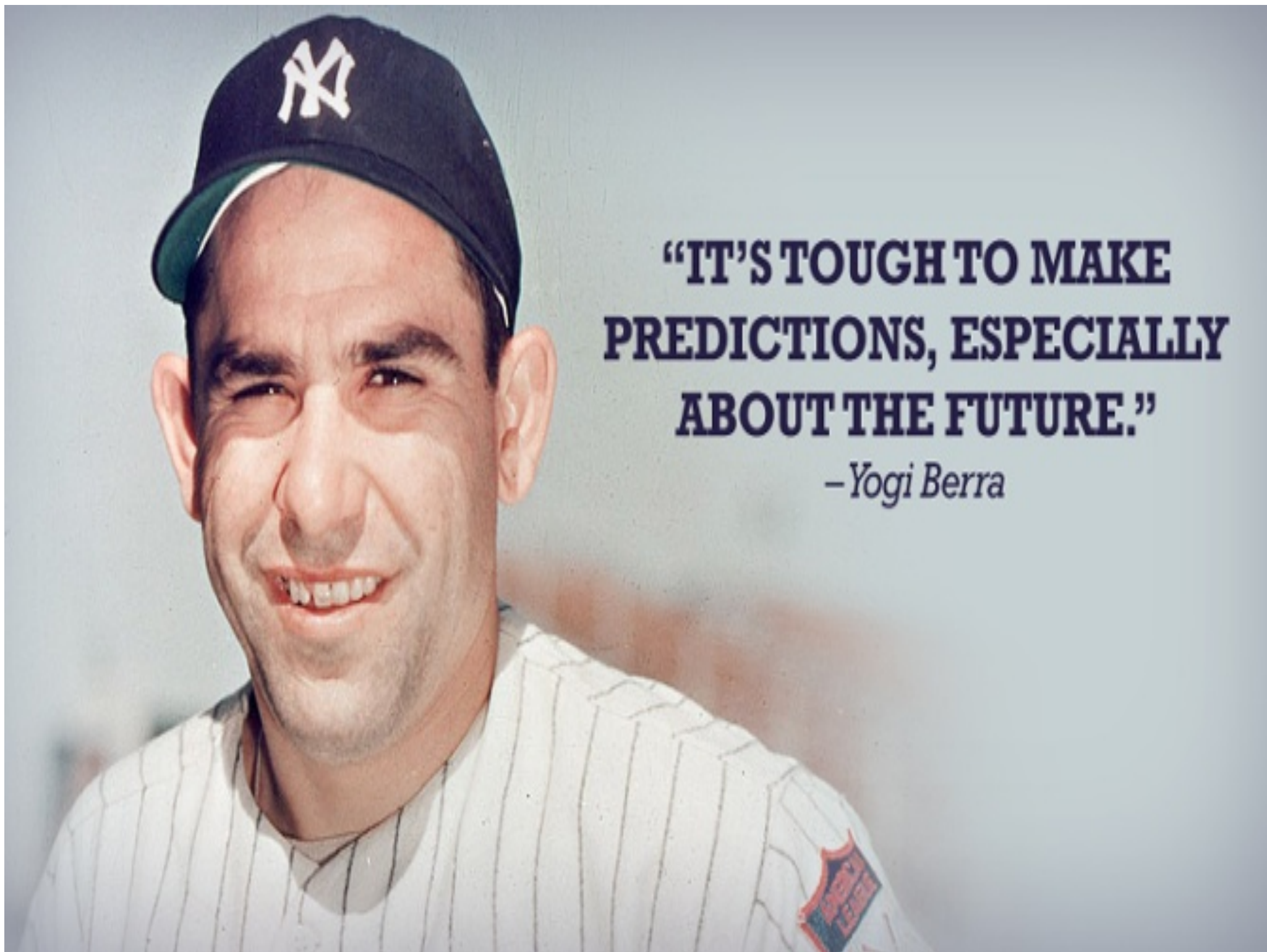
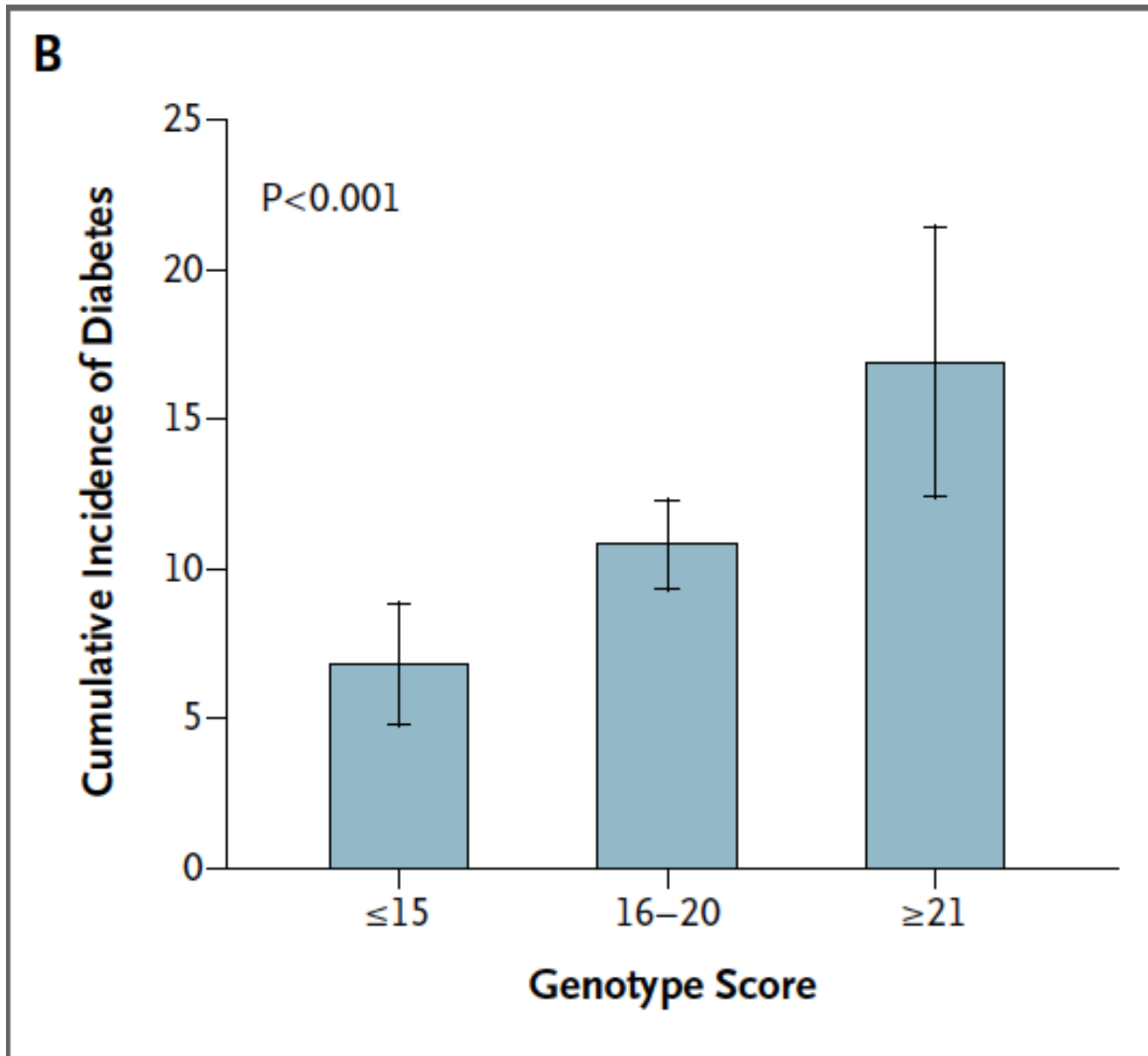


FIGURE 2. Probability distributions of a marker, X , in cases (solid curves) and controls (dashed curves) consistent with the logistic model $\log\text{-it}P(D=1|X) = \alpha + \beta X$. It has been assumed that X has a mean of 0 and a standard deviation of 0.5 in controls so that a unit increase represents the difference between the 84th and 16th percentiles of X in controls. The marker is normally distributed, with the same variance in cases. The odds ratio (OR) per unit increase in X is shown.

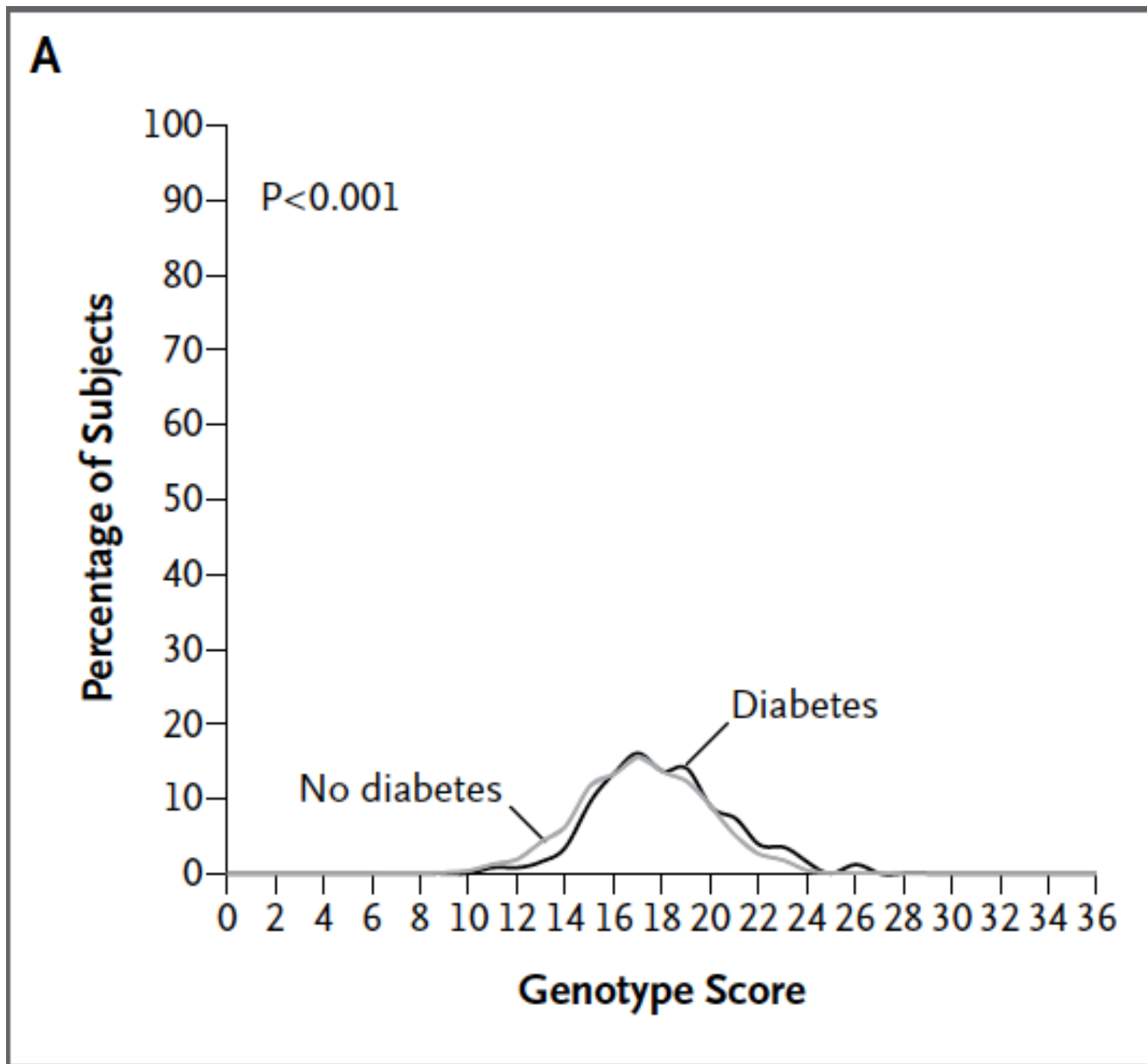


**“IT’S TOUGH TO MAKE
PREDICTIONS, ESPECIALLY
ABOUT THE FUTURE.”**

—Yogi Berra



Meigs JB, Shrader P, Sullivan LM, McAteer JB, Fox CS, Dupuis J, Manning AK, Florez JC, Wilson PW, D'Agostino RB Sr, Cupples LA. Genotype score in addition to common risk factors for prediction of type 2 diabetes. N Engl J Med. 2008 Nov 20;359(21):2208-19



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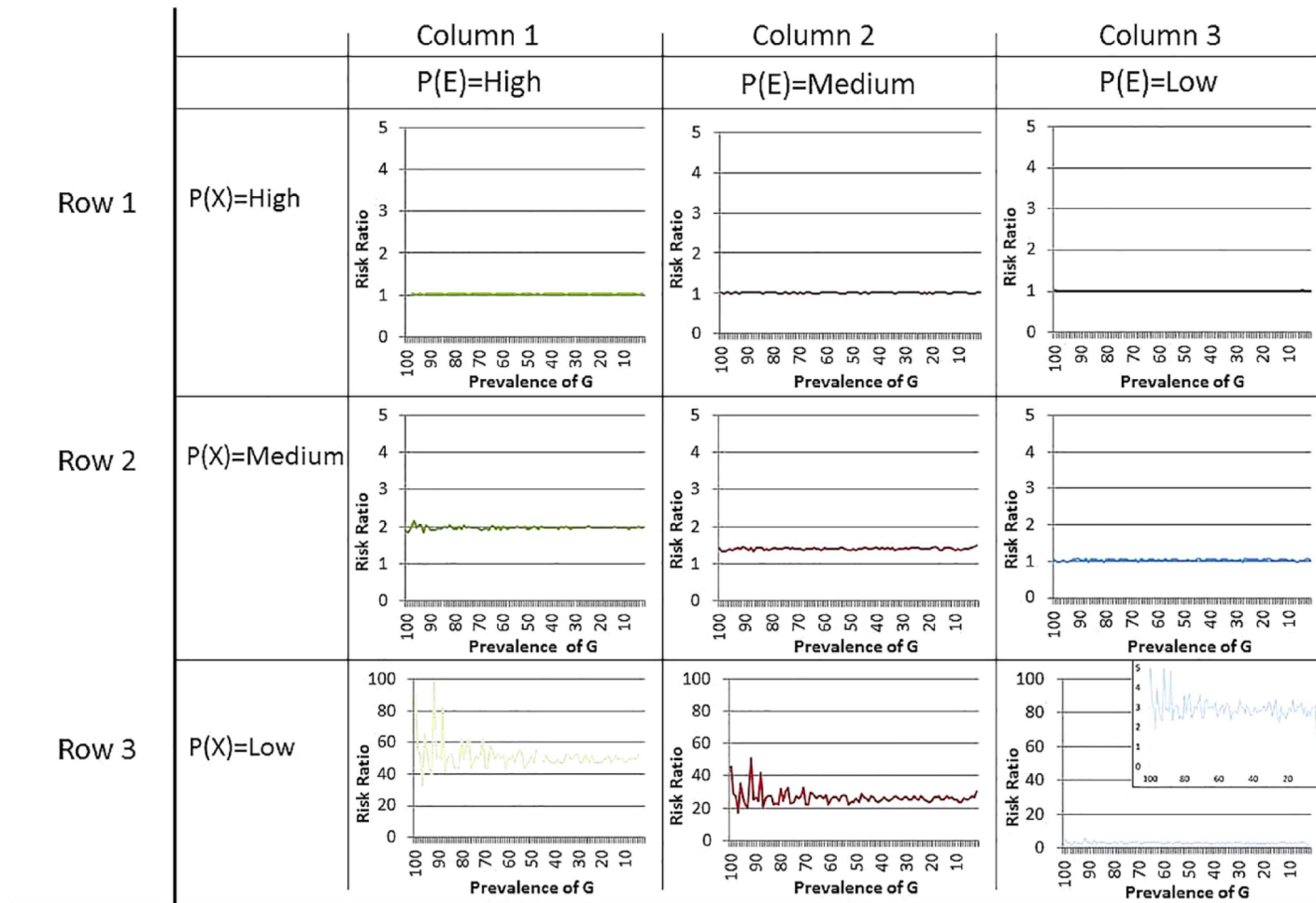


Figure 1 Risk ratio for the effect of gene on disease across prevalences of environmental variables and background rate of disease. G=genetic cause of disease. E=environmental cause of disease; the environmental cause requires presence in order for the genetic marker to have an effect. X=background rate of the disease—all causes that are not either G or E. Graph: y axis=risk ratio for the effect of genetic marker on disease; x axis=prevalence of genetic marker in each population.

Observation 1

At any G prevalence, the determinant of the magnitude of the risk ratio and the risk difference is prevalence of the E and X

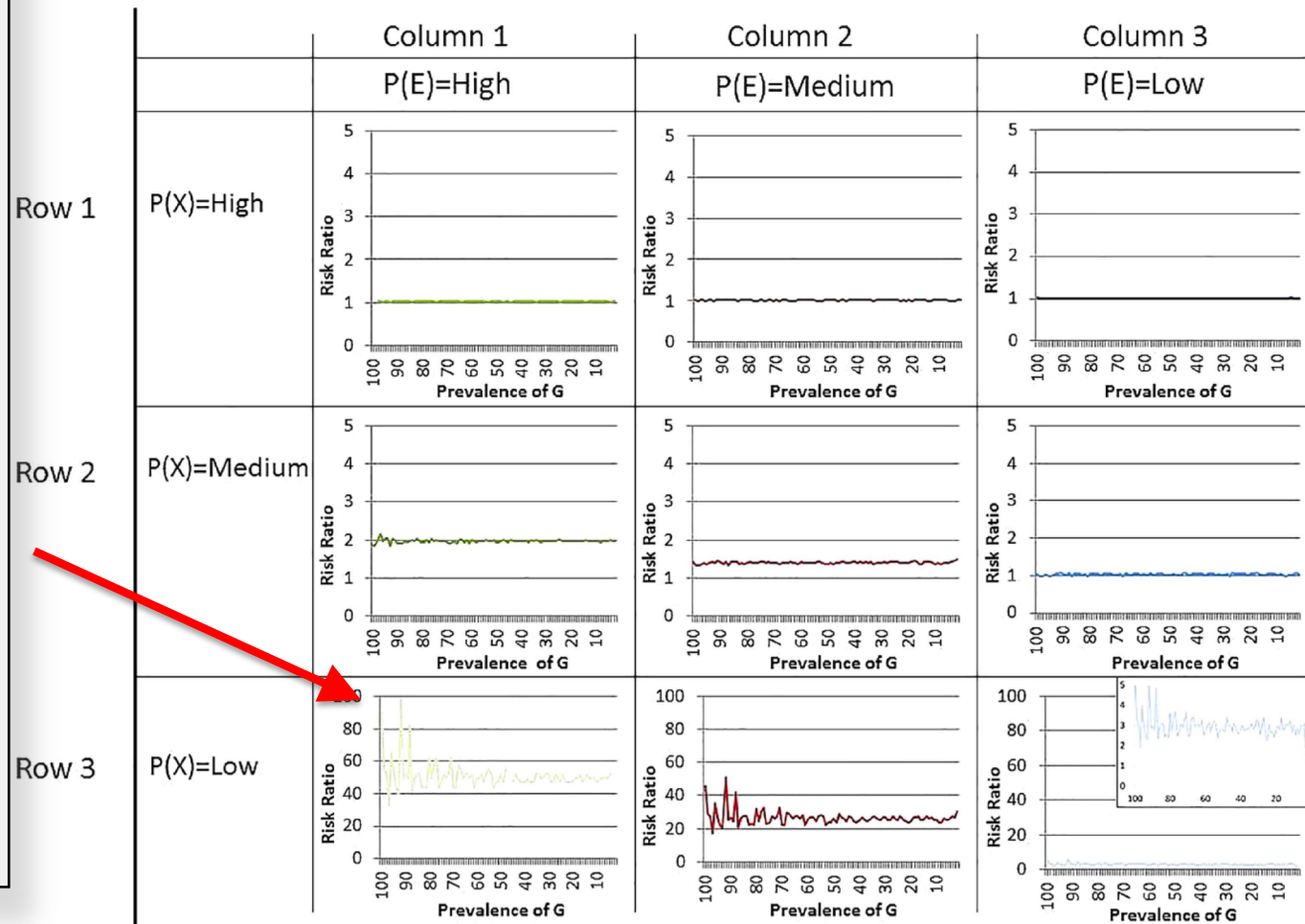


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Observation 1

At every G prevalence, the risk ratio and the risk difference increases as the prevalence of E increases

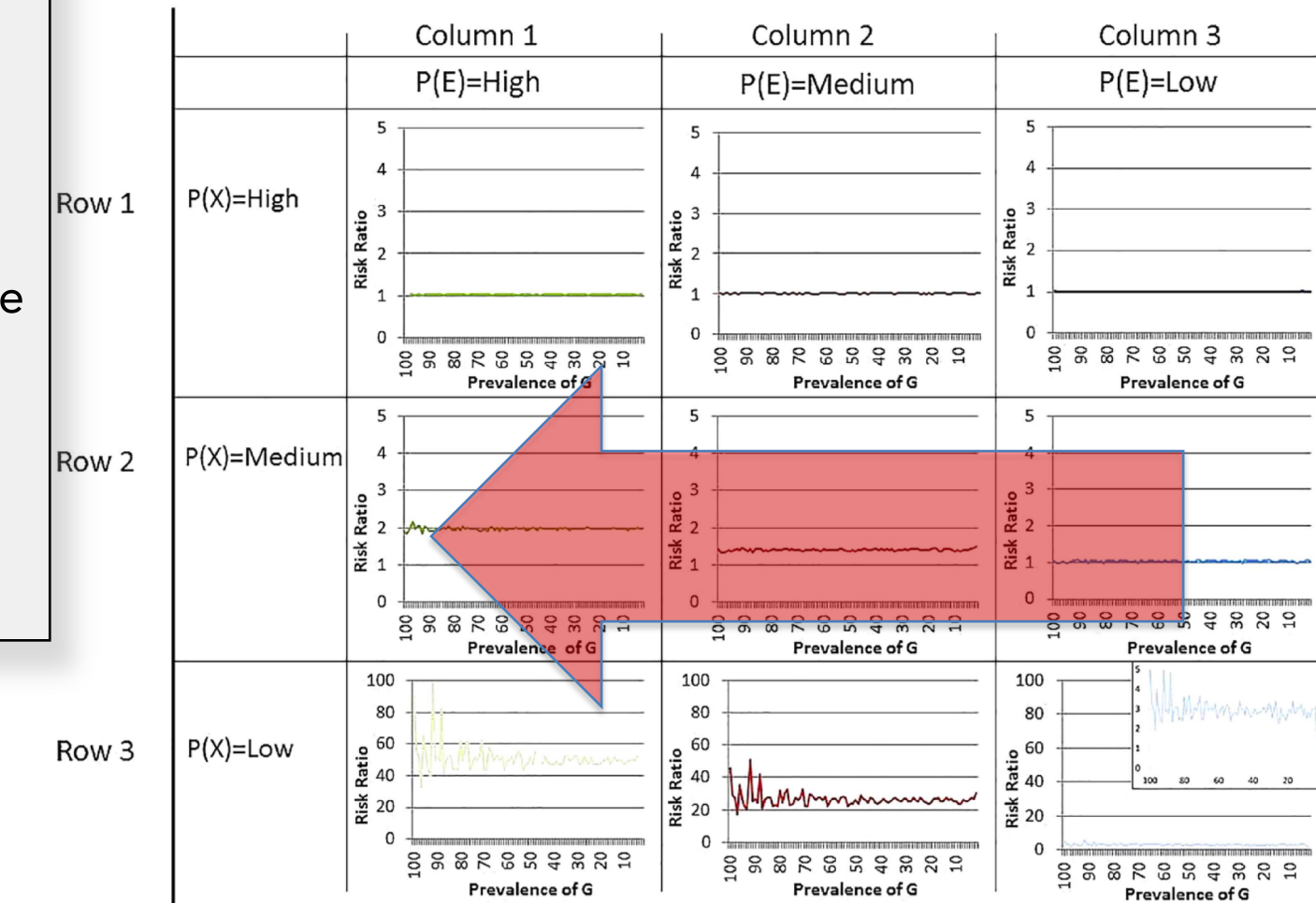


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Observation 1

At every G prevalence, the risk ratio decreases as the background rate of disease increases

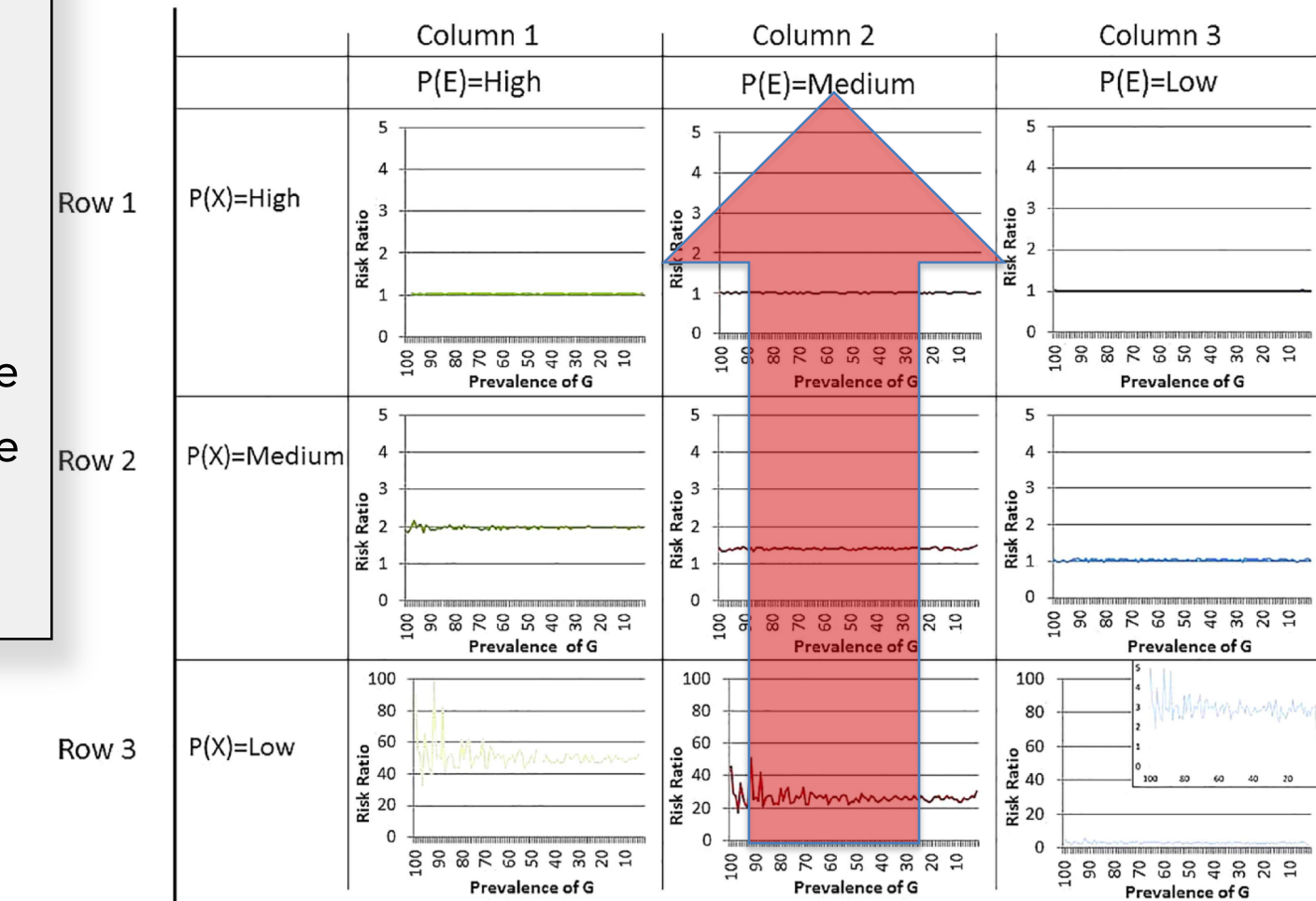


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Grounding this in a conceptual framework

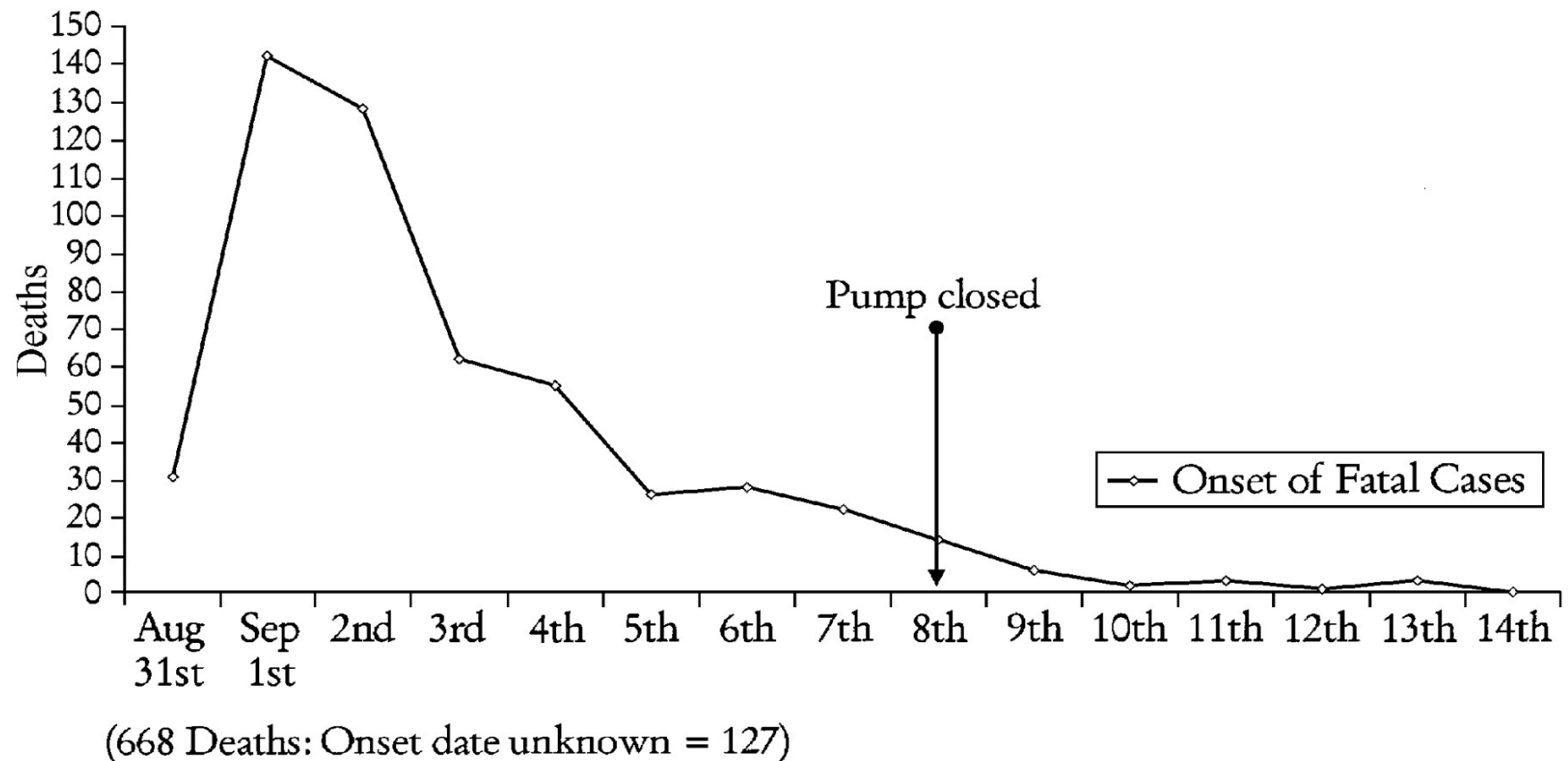
1. Population health manifests as a continuum.
2. The causes of differences in health across populations are not necessarily an aggregate of the causes of differences in health within populations.
3. Large benefits to population health may not improve the lives of all individuals.
4. The causes of population health are multilevel, accumulate throughout the life course, and are embedded in dynamic interpersonal relationships.
5. Small changes in ubiquitous causes may result in more substantial change in the health of populations than larger changes in rarer causes.
6. The magnitude of an effect of exposure on disease is dependent on the prevalence of the factors that interact with that exposure.
7. Prevention of disease often yields a greater return on investment than curing disease after it has started.
8. Efforts to improve overall population health may be a disadvantage to some groups; whether equity or efficiency is preferable is a matter of values.
9. We can predict health in populations with much more certainty than we can predict health in individuals.

The past as prologue

Simple approaches, a foundational myth



The effectiveness of simple approaches?



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