

Applications of Causal Inference Methods**Winter 2021 Remote Asynchronous Instruction**

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Course web page: <http://rogosateaching.com/stat209/>

Course Welcome and Logistics (first day stuff, posted in December, call it Week0)

Lecture slides, week 0 (pdf) **Audio companion, week 0**

For recreation of in-classroom experience, linked below are youtube versions of the music I play [before starting lecture](#) and [after lecture concludes](#). Some may wish to reverse that ordering.

Registrar's Information

Statistics 209B (also EPI 239, EDUC 260A) 2 units

Title: Applications of Causal Inference Methods

Description: **Application of potential outcomes formulation for causal inference to research settings** including: mediation, compliance adjustments, time-1 time-2 designs, encouragement designs, heterogeneous treatment effects, aggregated data, instrumental variables, analysis of covariance regression adjustments, and implementations of matching methods.

see class website <http://rogosateaching.com/stat209/>

suggested prerequisite **STAT209A/MSE327 or other introduction to causal inference methods.**

Course Overview

Note: This course was structured before the new world order of March 2020 as one two-hour class meeting per week.

Regard the class meeting time as **Wednesday afternoon**: (latest) time of posting for the week's lecture and materials.

Brief Course Outline

Weeks 1 - 3. Encouragement Designs; Mediation and Moderation in experimental and observational studies; Compliance adjustments; Multilevel data and Context Effects.

Week 4. Instrumental Variables methods for observational studies

Week 5. Analysis of Covariance adjustments in observational studies;

Systematic assignment based on a covariate, Analysis of Regression Discontinuity Designs

Weeks 6 - 7. Introduction and implementation of matching methods for observational studies.

Week 8 - 9. Time 1, Time 2 data: analysis of longitudinal designs for experimental and observational studies.

Dead Week. Overflow, Course recap.

[Lectures, Course Files, and Readings](#)

Grading, Exams, and Credit Units

Stat209B/EPI239/Ed260A is listed as **Letter or Credit/No Credit grading for 2-units**

For Winter 2021 grading for the 2-units will be based on a 'take home'(i.e. do at home) Problem Set.

Course Problem Set 2021 to be posted

Statistical computing

Class presentation will be in, and students are encouraged to use, **R** (occasionally, some references to SAS and Mathematica).

Current version of R is R version 4.0.3 released 2020-10-10

For references and software: [The R Project for Statistical Computing](#) Closest download mirrors in the past, UCLA and Berkeley, seem no longer available, pick your fave anywhere in the world.

The **CRAN Task Views** provide useful overviews/navigation for the almost infinite set of R-packages. Task Views that cover contents of this course include

[CRAN Task View: Statistics for the Social Sciences](#); [CRAN Task View: Econometrics](#) and [CRAN Task View: Psychometric Models and Methods](#).

Relevant Texts (optional).

Causal Inference in Statistics, Social and Biomedical Sciences: An Introduction, Guido Imbens and Don Rubin, 1st Edition (Cambridge University Press)

[Stanford access](#)

Design of Observational Studies, Paul Rosenbaum, 1st Edition (Springer). Available online: [Stanford access](#)

To see full course materials from **legacy Stat209 (2005-2019)**

Statistical Methods for Group Comparisons and Causal Inference [go here](#)



OCCASIONAL NOTES

Chocolate Consumption, Cognitive Function,
and Nobel Laureates

Franz H. Messerli, M.D.

Dietary flavonoids, abundant in plant-based foods, have been shown to improve cognitive function. Specifically, a reduction in the risk of dementia, enhanced performance on some cognitive tests, and improved cognitive function in elderly patients with mild impairment have been associated with a regular intake of flavonoids.^{1,2} A subclass of flavonoids called flavanols, which are widely present in cocoa, green tea, red wine, and some fruits, seems to be effective in slowing down or even reversing the reductions in cognitive performance that occur with aging. Dietary flavanols have also been shown to improve endothelial function and to lower blood pressure by causing vasodilation in the peripheral vasculature and in the brain.^{3,4} Improved cognitive performance with the administration of a cocoa polyphenolic extract has even been reported in aged Wistar-Unilever rats.⁵

Since chocolate consumption could hypothetically improve cognitive function not only in individuals but also in whole populations, I wondered whether there would be a correlation between a country's level of chocolate consumption and its population's cognitive function. To my knowledge, no data on overall national cognitive function are publicly available. Conceivably, however, the total number of Nobel laureates per capita could serve as a surrogate end point reflecting the proportion with superior cognitive function and thereby give us some measure of the overall cognitive function of a given country.

METHODS

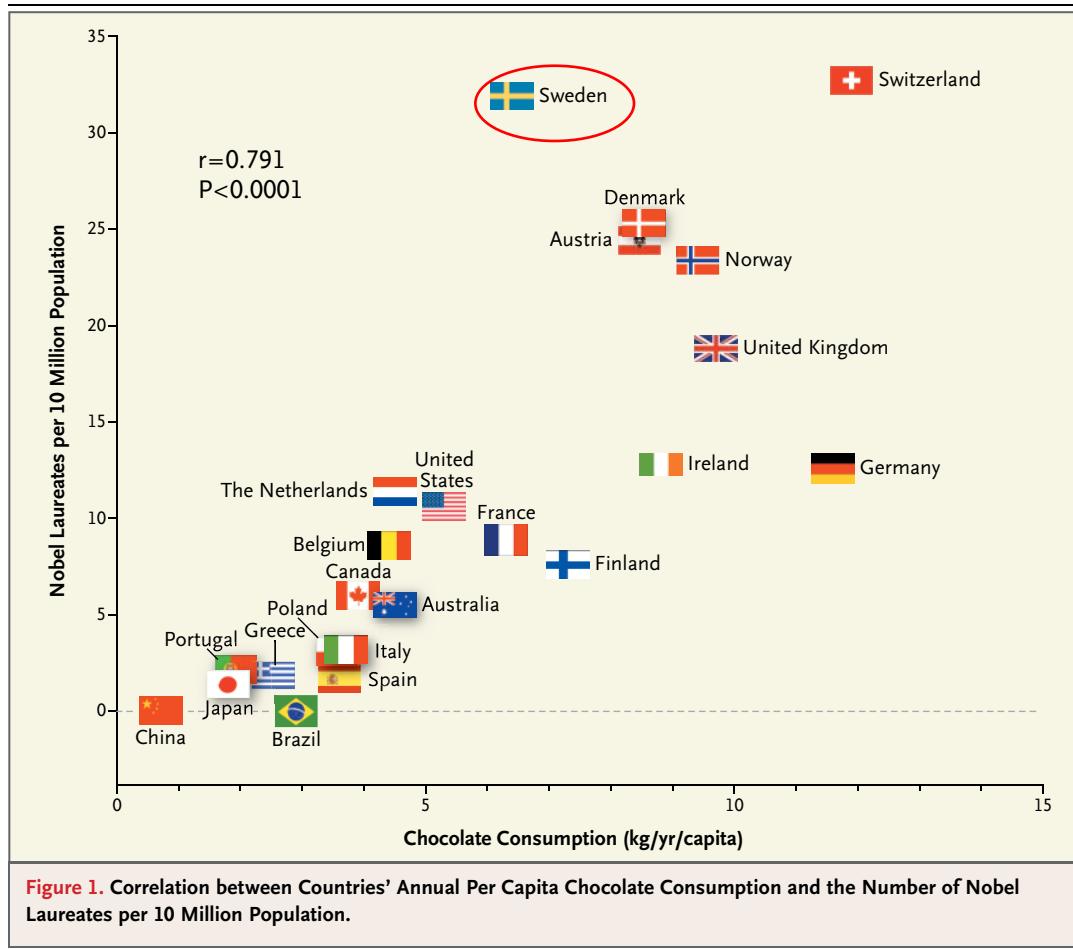
A list of countries ranked in terms of Nobel laureates per capita was downloaded from Wikipedia (http://en.wikipedia.org/wiki/List_of_countries_by_Nobel_laureates_per_capita). Be-

cause the population of a country is substantially higher than its number of Nobel laureates, the numbers had to be multiplied by 10 million. Thus, the numbers must be read as the number of Nobel laureates for every 10 million persons in a given country.

All Nobel Prizes that were awarded through October 10, 2011, were included. Data on per capita yearly chocolate consumption in 22 countries was obtained from Chocosuisse (www.chocosuisse.ch/web/chocosuisse/en/home), Theobroma-cacao (www.theobroma-cacao.de/wissen/wirtschaft/international/konsum), and Caobisco (www.caobisco.com/page.asp?p=213). Data were available from 2011 for 1 country (Switzerland), from 2010 for 15 countries, from 2004 for 5 countries, and from 2002 for 1 country (China).

RESULTS

There was a close, significant linear correlation ($r=0.791$, $P<0.0001$) between chocolate consumption per capita and the number of Nobel laureates per 10 million persons in a total of 23 countries (Fig. 1). When recalculated with the exclusion of Sweden, the correlation coefficient increased to 0.862. Switzerland was the top performer in terms of both the number of Nobel laureates and chocolate consumption. The slope of the regression line allows us to estimate that it would take about 0.4 kg of chocolate per capita per year to increase the number of Nobel laureates in a given country by 1. For the United States, that would amount to 125 million kg per year. The minimally effective chocolate dose seems to hover around 2 kg per year, and the dose-response curve reveals no apparent ceiling on the number of Nobel laureates at the highest chocolate-dose level of 11 kg per year.



DISCUSSION

The principal finding of this study is a surprisingly powerful correlation between chocolate intake per capita and the number of Nobel laureates in various countries. Of course, a correlation between X and Y does not prove causation but indicates that either X influences Y, Y influences X, or X and Y are influenced by a common underlying mechanism. However, since chocolate consumption has been documented to improve cognitive function, it seems most likely that in a dose-dependent way, chocolate intake provides the abundant fertile ground needed for the sprouting of Nobel laureates. Obviously, these findings are hypothesis-generating only and will have to be tested in a prospective, randomized trial.

The only possible outlier in Figure 1 seems to be Sweden. Given its per capita chocolate consumption of 6.4 kg per year, we would predict that Sweden should have produced a total of

about 14 Nobel laureates, yet we observe 32. Considering that in this instance the observed number exceeds the expected number by a factor of more than 2, one cannot quite escape the notion that either the Nobel Committee in Stockholm has some inherent patriotic bias when assessing the candidates for these awards or, perhaps, that the Swedes are particularly sensitive to chocolate, and even minuscule amounts greatly enhance their cognition.

A second hypothesis, reverse causation — that is, that enhanced cognitive performance could stimulate countrywide chocolate consumption — must also be considered. It is conceivable that persons with superior cognitive function (i.e., the cognoscenti) are more aware of the health benefits of the flavanols in dark chocolate and are therefore prone to increasing their consumption. That receiving the Nobel Prize would in itself increase chocolate intake countrywide seems unlikely, although perhaps celebratory events associated with this unique

honor may trigger a widespread but most likely transient increase.

Finally, as to a third hypothesis, it is difficult to identify a plausible common denominator that could possibly drive both chocolate consumption and the number of Nobel laureates over many years. Differences in socioeconomic status from country to country and geographic and climatic factors may play some role, but they fall short of fully explaining the close correlation observed.

STUDY LIMITATIONS

The present data are based on country averages, and the specific chocolate intake of individual Nobel laureates of the past and present remains unknown. The cumulative dose of chocolate that is needed to sufficiently increase the odds of being asked to travel to Stockholm is uncertain. This research is evolving, since both the number of Nobel laureates and chocolate consumption are time-dependent variables and change from year to year.

CONCLUSIONS

Chocolate consumption enhances cognitive function, which is a sine qua non for winning the

Nobel Prize, and it closely correlates with the number of Nobel laureates in each country. It remains to be determined whether the consumption of chocolate is the underlying mechanism for the observed association with improved cognitive function.

Dr. Messerli reports regular daily chocolate consumption, mostly but not exclusively in the form of Lindt's dark varieties.

Disclosure forms provided by the author are available with the full text of this article at NEJM.org.

From St. Luke's–Roosevelt Hospital and Columbia University, New York.

This article was published on October 10, 2012, at NEJM.org.

1. Nurk E, Refsum H, Drevon CA, et al. Intake of flavonoid-rich wine, tea, and chocolate by elderly men and women is associated with better cognitive test performance. *J Nutr* 2009;139:120-7.
2. Desideri G, Kwik-Urbe C, Grassi D, et al. Benefits in cognitive function, blood pressure, and insulin resistance through cocoa flavanol consumption in elderly subjects with mild cognitive impairment: the Cocoa, Cognition, and Aging (CoCoA) Study. *Hypertension* 2012;60:794-801.
3. Corti R, Flammer AJ, Hollenberg NK, Lüscher TF. Cocoa and cardiovascular health. *Circulation* 2009;119:1433-41.
4. Sorond FA, Lipsitz LA, Hollenberg NK, Fisher ND. Cerebral blood flow response to flavanol-rich cocoa in healthy elderly humans. *Neuropsychiatr Dis Treat* 2008;4:433-40.
5. Bisson JF, Nejdi A, Rozan P, Hidalgo S, Lalonde R, Messaoudi M. Effects of long-term administration of a cocoa polyphenolic extract (Acticoa powder) on cognitive performances in aged rats. *Br J Nutr* 2008;100:94-101.

DOI: 10.1056/NEJMon1211064

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AN NEJM APP FOR IPHONE

The NEJM Image Challenge app brings a popular online feature to the smartphone. Optimized for viewing on the iPhone and iPod Touch, the Image Challenge app lets you test your diagnostic skills anytime, anywhere. The Image Challenge app randomly selects from 300 challenging clinical photos published in NEJM, with a new image added each week. View an image, choose your answer, get immediate feedback, and see how others answered. The Image Challenge app is available at the iTunes App Store.

WEEK4

whether there would be a correlation between a country's level of chocolate consumption and its population's cognitive function." Using the success of a country in winning Nobel Prizes as a surrogate for "the proportion with superior cognitive function" in a country, he analyzed the relationship between the number of Nobel laureates per capita in a country with that country's per capita chocolate consumption.

Messerli reported "a close, significant linear correlation ($r=0.791$, $p<0.0001$) between chocolate consumption per capita and the number of Nobel laureates per 10 million persons in a total of 23 countries." The relationship was even stronger when Sweden, the home of the Nobel Prize, was removed from the calculations, as it appeared to have won more Nobel prizes than expected based on its chocolate consumption. Switzerland, on the other hand, "was the top performer in terms of both the number of Nobel Laureates and chocolate consumption." (It should perhaps be noted at this point that Messerli, a hypertension expert who lives in New York City, was born in Switzerland and reports in his disclosure statement that he consumes chocolate daily, "mostly but not exclusively in the form of Lindt's dark varieties.")

Messerli duly points out that correlation does not prove causation, but, he writes, "since chocolate consumption has been documented to improve cognitive function, it seems most likely that in a dose-dependent way, chocolate intake provides the abundant fertile ground needed for the sprouting of Nobel laureates. Obviously, these findings are hypothesis-generating only and will have to be tested in a prospective, randomized trial."

Regarding Sweden's status as an outlier, Messerli writes that "one cannot quite escape the notion that either the Nobel Committee in Stockholm has some inherent patriotic bias when assessing the candidates for these awards or, perhaps, that the Swedes are particularly sensitive to chocolate, and even

The author is a Forbes contributor. The opinions expressed are those of the writer.

LARRY HUSTEN'S POPULAR POSTS

[Study Finds Sodium-Potassium Ratio Strongly Tied to Mortality and CV Disease](#) 34,222 views

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[Resveratrol and Fraud](#) 23,437 views

MORE FROM LARRY HUSTEN

CORRELATION AND CAUSATION

a comment

STEPHEN STIGLER

ABSTRACT Some purely methodological comments are made on the pitfalls and difficulties in making causal inferences from observational data, including in studies of disparity in medicine. The ideas of spurious correlation and measurement error are discussed with an eye towards their impact upon inferences about causality, and cautions are offered about over-reliance upon testing hypotheses.

STATISTICIANS HAVE LONG STRUGGLED to deduce causal relationships from correlation; that is, to determine a mechanistic relationship from purely empirical evidence of association. That is also the essential goal of the methods that are being discussed here. There are other important issues to be sure, such as whether or not the deduced causal relationship is illegal or immoral, but statistically that is secondary to the study of the nature of the relationship. The answer to the strict question “Can cause be deduced from correlation?” is generally “no.” But necessity being the mother of invention, we do it anyway, by weakening the question to one permitting a more positive answer: “Under certain restrictive assumptions, can we conclude causation from correlation, beyond a reasonable doubt?” In that form a great deal of methodological progress has been made, including by one of this year’s Nobel Prize–winning economists, Clive Granger. But the answer to the strict question remains “no,” and it may be worthwhile recalling why that is so.

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Freedman text includes a series of older social science publications as case studies.

1. Smart Babies

Upside

a. [Breastfeeding Boosts Kids' Brains, Especially Boys' Do Breast-Fed Baby Boys Grow Into Better Students?](#) Publication: [Breastfeeding Duration and Academic Achievement at 10 Years](#). Wendy H. Oddy, Jianghong Li, Andrew J. O. Whitehouse, Stephen R. Zubrick, Eva Malacova. *Pediatrics*; Vol 127, Numb 1, Jan 2011

b. [Extended Womb Time Makes Better Students. More time in womb tied to better academic performance later in life](#) Publication: Noble KG, et al. [Academic achievement varies with gestational age among children born at term](#) *Pediatrics* 2012; DOI: 10.1542/peds.2011-2157.

Downside

c. [Moderate drinking in pregnancy 'harms IQ' Just one glass of wine a week while pregnant 'can harm a baby's IQ'](#) Publication: [Fetal Alcohol Exposure and IQ at Age 8: Evidence from a Population-Based Birth-Cohort Study](#). PLoS ONE 7(11): e49407. doi:10.1371/journal.pone.0049407

2. Is TV bad or is it bad parenting? Attention Deficit Disorder and TV

and should the question be answered with LISREL (structural equation models)

2004 version: *Pediatrics*. 2004;113:708-713. Christakis DA, Zimmerman FJ, DiGiuseppe DL, McCarty CA. Early television exposure and subsequent attentional problems in children.

[Publication](#) [press release](#) [audio NPR interview](#)

2006 reversal? (with LISREL) *Pediatrics*. March 2006. Stevens T and Mulsow M. There is no meaningful relationship between television exposure and symptoms of attention-deficit hyperactivity disorder. *Pediatrics*. 2006; 117(3):665-672.

News Reports: [TV may not cause kids' attention disorders](#) [Researchers say TV is not to blame for ADHD](#)

Good general commentary in [Slate Feb '06](#) The Benefits of Bozo Proof that TV doesn't harm kids.

Or maybe it is what you eat?

[Diet May Help ADHD Kids More Than Drugs](#) [Food additives and hyperactive behaviour in 3-year-old and 8/9-year-old children in the community](#): a randomised, double-blinded, placebo-controlled trial.

Or maybe it is genetic?

[Study finds first evidence that ADHD is genetic](#) [Clues to the Genetic Roots of ADHD](#) Publication: [Rare chromosomal deletions and duplications in attention-deficit hyperactivity disorder: a genome-wide analysis](#) *The Lancet*, Volume 376, Issue 9750, Pages 1401 - 1408, 23 October 2010

Or Domestic Violence?

[Childhood ADHD, Conduct Disorder Linked to Intimate Partner Violence](#) [Childhood ADHD, Conduct Disorder Linked to Intimate Partner Violence](#)

Auxiliary notes This research example raises an important theme of this course-- similarities (often indistinguishability) between social science and medical research. Is the TV and ADHD child development or medical research? (point being the division is often unclear or unuseful)

further aside: ADHD medication: [Prescribing of hyperactivity drugs is out of control](#) [ADHD on the Rise: Almost One in 10 Children Diagnosed, Says CDC](#);

As with most important issues, definitive wisdom is provided by *South Park* via [Cartman](#): here, episode 404 (4/19/2000), [episode summary](#) and [episode video](#)

3. Money and Happiness

[Would You Be Happier If You Were Richer? A Focusing Illusion](#)

Science 30 June 2006: Vol. 312, no. 5782, pp. 1908 - 1910, Daniel Kahneman Alan B. Krueger, David Schkade, Norbert Schwarz, Arthur A. Stone

Or is it age-dependent? [The Midlife Happiness Crisis](#) [Is Well-being U-Shaped over the Life Cycle?](#) David G. Blanchflower, Andrew Oswald NBER Working Paper No. 12935 February 2007.

Same for Apes? [Evidence for a midlife crisis in great apes consistent with the U-shape in human well-being](#) PNAS, Proceedings of the National Academy of Sciences, 2012

It's not TV? [Unhappy People Watch TV, Happy People Read/Socialize](#) Publication [What Do Happy People Do?](#) John P. Robinson and Steven Martin *Soc Indic Res* (2008) 89:565-571

[Is Happiness Overrated? Study Finds Physical Benefits to Some \(Not All\) Good Feelings](#)

Or, instead, does money cause evil? [Shame on the Rich](#) *Science News*, February 2012. [Higher social class predicts increased unethical behavior](#) PNAS 2012

4. Kindergarten and Money

[\\$320,000 Kindergarten Teachers](#)

Paper: [HOW DOES YOUR KINDERGARTEN CLASSROOM AFFECT YOUR EARNINGS? EVIDENCE FROM PROJECT STAR](#) Raj Chetty, Harvard University and NBER John N. Friedman, Harvard University and NBER Nathaniel Hilger, Harvard University Emmanuel Saez, UC Berkeley and NBER Diane Whitmore Schanzenbach, Northwestern University and NBER Danny Yagan, Harvard University March 2011. [Policy Brief, Kennedy School of Government](#) Talks: [How Does Your Kindergarten Classroom Affect Your Earnings? Evidence from Project STAR](#) Raj Chetty, Harvard [another version](#)

Using R. Tennessee's Student Teacher Achievement Ratio (STAR) from [Creating an R data set from STAR](#) Douglas Bates

Other Studies: [Long-Term Effects of Class Size](#) Peter Fredriksson, Bjorn Ockert and Hessel Oosterbeek The Quarterly Journal of Economics (2012)

[Effect of Class Size in Grades K-3 on Adult Earnings, Employment, and Disability Status](#): Evidence from a Multi-center Randomized Controlled Trial Elizabeth Ty Wilde, PhD Jeremy Finn, PhD Gretchen Johnson, MA Peter Muennig, MD, MPH Journal of Health Care for the Poor and Underserved 22 (2011): 1424-1435.

More economists on Early Education: Jim Heckman. [It Pays to Invest in Early Education Says a Nobel Economist Who Boosts Kids' IQ](#)

5. Beer and productivity

NY Times: [For Scientists, a Beer Test Shows Results as a Litmus Test](#) Slashdot [Scientists' Success Or Failure Correlated With Beer](#) but [Beer-Drinking Scientist Debunks Productivity Correlation](#) 21/03: [In Defense of Beer-Drinking Scientists](#)

Publication. [A possible role of social activity to explain differences in publication output among ecologist](#) Thomas Grim *Oikos*, 2008 [Abstract](#) [Beer Scatterplot](#)

Collection: [Beer vs. science -- first laugh, then think \(what to drink:-\)](#) Selection of media reports, interviews and commentaries on probably the most discussed ecological paper of the year 2008

Not too late: [Starting Drinking in Middle Age Reduces Cardiovascular Risk](#)

6. God and IQ

[High IQ turns academics into atheists](#)

[Why people who believe in God 'are more likely to have a lower IQ'](#)

Publication. Lynn, Richard; John Harvey and Helmut Nyborg. "Average intelligence predicts atheism rates across 137 nations". *Intelligence* 2008. Elsevier Inc. doi:10.1016/j.intell.2008.03.004

Wikipedia page [Religiosity and intelligence](#)

7. Media and Teen Vice

2006 version.

[Pediatrics 2006;117:1018-1027](#) Sexy Media Matter: Exposure to Sexual Content in Music, Movies, Television, and Magazines Predicts Black and White Adolescents' Sexual Behavior [UNC Teen Media Center](#) (NICHD funded)

2008 uproar, [RAND corp.](#)

[Sex-saturated TV shows making teens pregnant](#)

[Sex on TV linked to teen pregnancies: Watching lots of racy shows can affect adolescents over time](#)

Publication: [Does Watching Sex on Television Predict Teen Pregnancy?](#) Findings from a National Longitudinal Survey of Youth *Pediatrics*, v. 122, no. 5, Nov. 2008, p. 1047-1054

January 2012: Or are they just clueless??? [CDC: Many teen moms didn't think they would get pregnant](#) [Half of Teen Moms Don't Use Birth Control](#) --Why That's No Surprise

CDC Report, Jan 2012: [Prepregnancy Contraceptive Use Among Teens with Unintended Pregnancies Resulting in Live Births](#) - Pregnancy Risk Assessment Monitoring System (PRAMS), 2004-2008

the real truth on sex and rock-and-roll from [Frank Zappa](#): [Zappa on Crossfire 1987](#); [Zappa vs Tipper Gore on Nightline 1985 with Ted Koppel](#)