IOWA STATE UNIVERSITY
Food Science and Human Nutrition

Safety of Genetically Modified Foods and Food Ingredients

Ruth S. MacDonald, RD PhD
Professor and Chair

GMO in US food system

- Corn-derived ingredients
  - Oil, starch, corn syrup, alcohol
- Soybean-derived ingredients
  - Oil, soy flour, soy proteins, lecithin
- Canola oil
- Sugar from sugar beets

Found in most of processed foods

- Papaya, squash, sweet corn

Indirect GMO foods

- Animals fed GMO grain
  - Meat - beef, chicken, pork
  - Milk, yogurt, cheese, butter
  - Eggs

- Foods made with any of the above
  - Prepared meals
  - Baked goods
  - Desserts

Timeline of GMO in US Foods

1992 – FDA policy

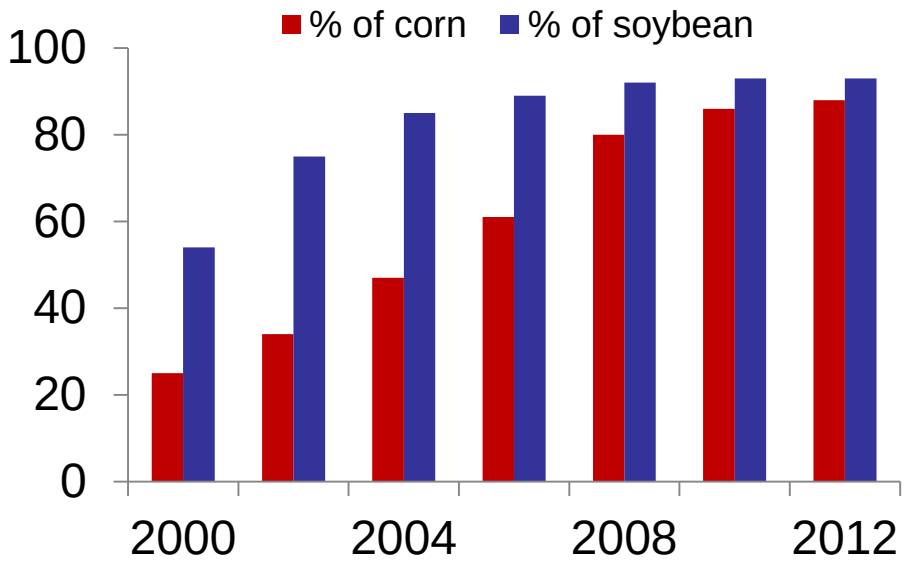
1994 – Tomato and squash

1996 – Corn, soybeans, canola

1998 – Papaya

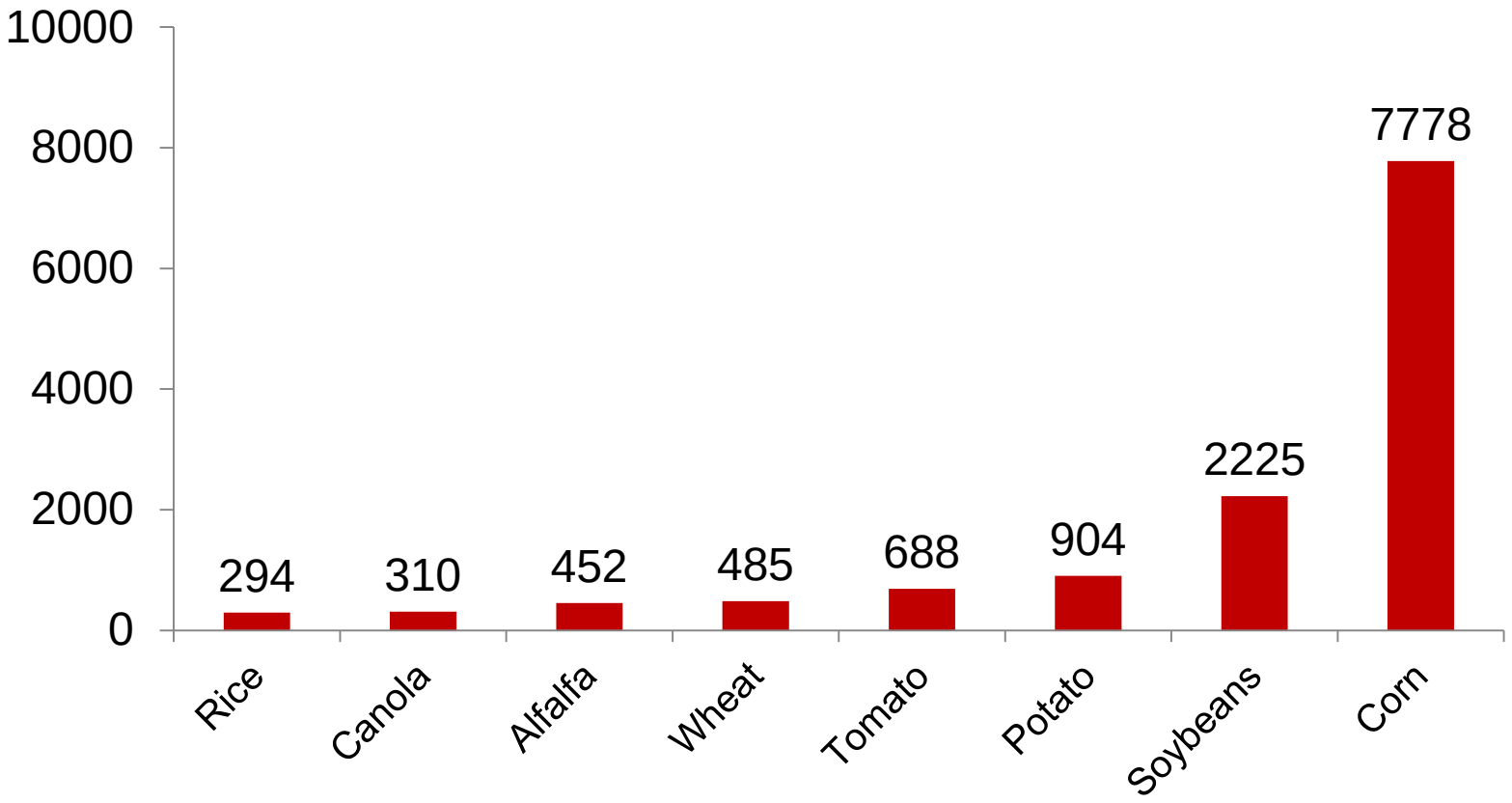
2008 – Sugar beets

2011 – High-oleic soybeans



www.foodinsight.org

Total APHIS permits 2013



USDA ERS, 2014

FDA policy on GMO foods

- 1986 Coordinated Framework for the Regulation of Biotechnology (CFRB)
  - Product not process
- 1992 substantial equivalence to conventional foods
- Voluntary submission

Safety measures

- **Toxicity**
  - genes, proteins or altered expression
- **Adverse nutritional changes**
  - anti-nutrients, altered expression
- **Allergenicity**
  - novel proteins
- **Horizontal gene transfer**
  - mutations

www.foodpolicy.umn.edu

Testing approaches

- Bioinformatics
  - database comparisons
- Digestibility/degradation
  - in vitro, pure compound
- Metabolomics
  - protein expression patterns
- Feeding trials
  - acute and chronic toxicity
- Field trials
  - environmental influences

http://www.monsanto.com/products/pages/stacked-product-safety-summaries.aspx

Safety testing

Tier I: Potential Hazard Identification

- History of Safe Use
- Bioinformatics Analysis
- Mode of Action and Specificity
- *In Vitro* Digestibility and Lability
- Expression Level and Dietary Intake

Tier II: Hazard Characterization

Determined on a case-by-case basis and might include one or more of the following:

- Acute toxicology assessment of transgenic protein
- Repeated dose toxicology assessment of transgenic protein
- Hypothesis-based Studies

Delaney et al, Food and Chemical Tox 46:S71-S97, 2008

Newly expressed proteins

- Foods contain many proteins
- Limited number of natural protein toxins
- Limited number of natural protein allergens
- Denaturation and enzyme digestion occurs

Delaney et al, Food and Chemical Tox 46:S71-S97, 2008

No substantiated allergenicity in humans to GM food or food ingredient with over 20 years of exposure

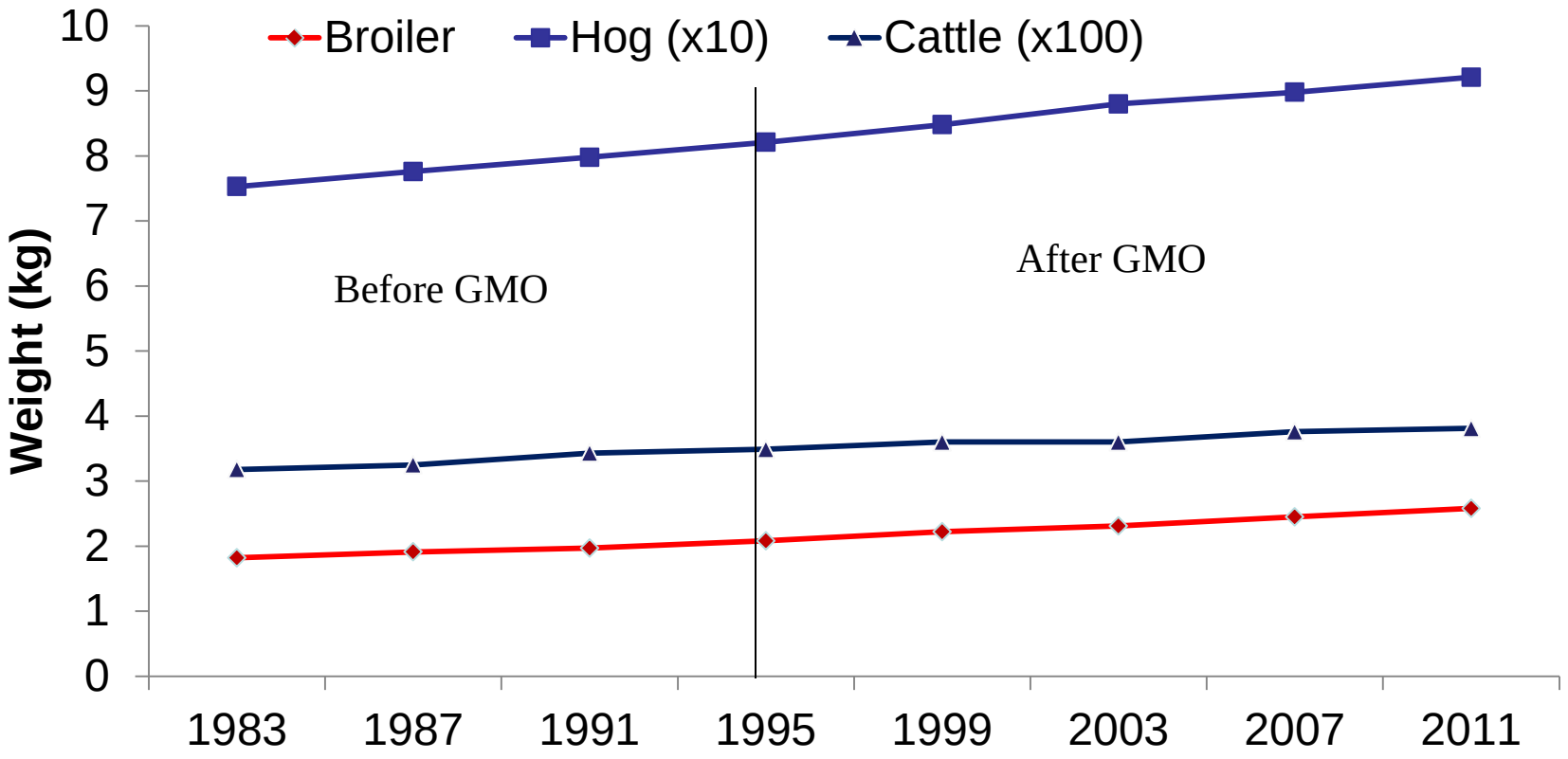
Livestock data

- 100 billion animals fed GMO grain between 2000-2011
- No difference in health outcomes comparing before after GMO introduction
- No difference in nutrient or food composition

Industry	U.S.
Broilers	94,683,600,000
Layer Hens	3,722,708,000
Turkeys	2,733,500,000
Beef cattle	339,350,000
Dairy cows	33,550,000
Hogs	1,219,460,000
Total	**102,732,168,000**

Van Eenennaam and Young, J Ani Sci, 2014

Livestock health



Van Eenennaam and Young, J Ani Sci, 2014

Safety studies in animals

- Native plant DNA-fragments may be absorbed with very low frequency
- Assume same for recombinant DNA
- No transfer of recombinant DNA from feed to animal tissues (eggs, meat or milk)

Flachowsky et al, Animal Feed Sci Tech 133:2-30, 2007

Gut microbiota

- Horizontal gene flow
- DNA rapidly degraded by digestion
- Limited amount may escape to colon
- Native and recombinant DNA similar

Transformation of gut microbiota highly unlikely

European Commission: A Decade of EU-funded GMO Research (2001-2010)
http://ec.europa.eu/research

Genome stability

"*No evidence that a random genomic change in a crop has ever resulted in a novel safety issue, even when new alleles or genes were created*"

Weber, Halpin, Hannah and Jez. Crop Genome Plasticity and Its Relevance to Food and Feed Safety of Genetically Engineered Breeding Stacks, Plant Physiol 160:1842-1853, 2012

http://www.plantphysiol.org/cgi/doi/10.1104/pp.112.204271

Human health

- Consumption began 20 years ago
- No documented evidence for health risks
- Exposure rate is low
  - Processing of grains
  - Extraction of ingredients
  - Heat treatment
  - Low relative component of food

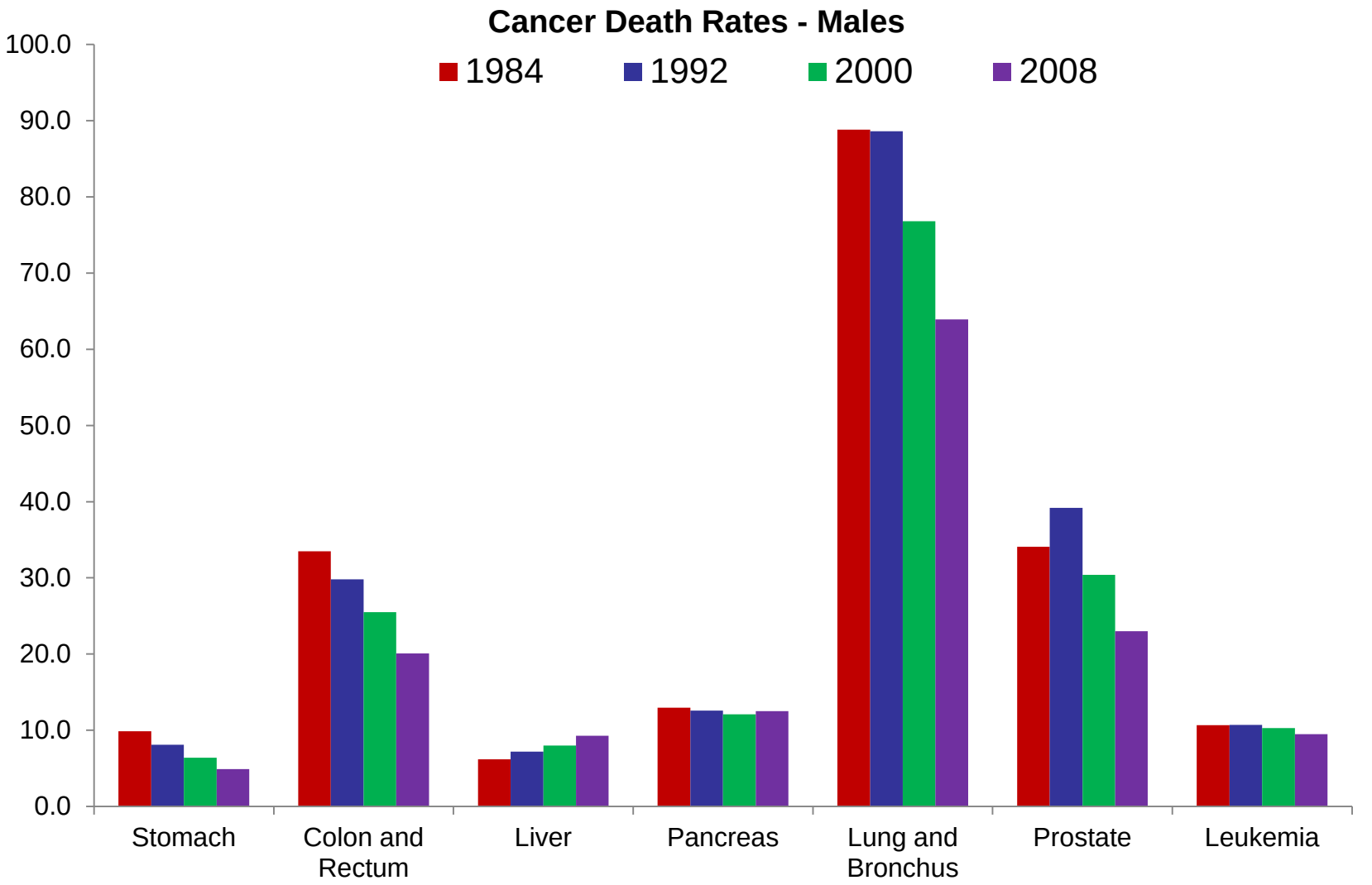
Implied correlations

Prevalent health issues

- Obesity
- Cancer
- Food allergies
- Gluten insensitivity
- Autism
- ADHD
- Alzheimer's disease
- Depression
- Heart disease

Complex etiologies

- Foods and food patterns
- Lifestyle
- Chemical exposures
  - Pollutants
  - Endocrine disruptors
- Genetics
- Epigenetics



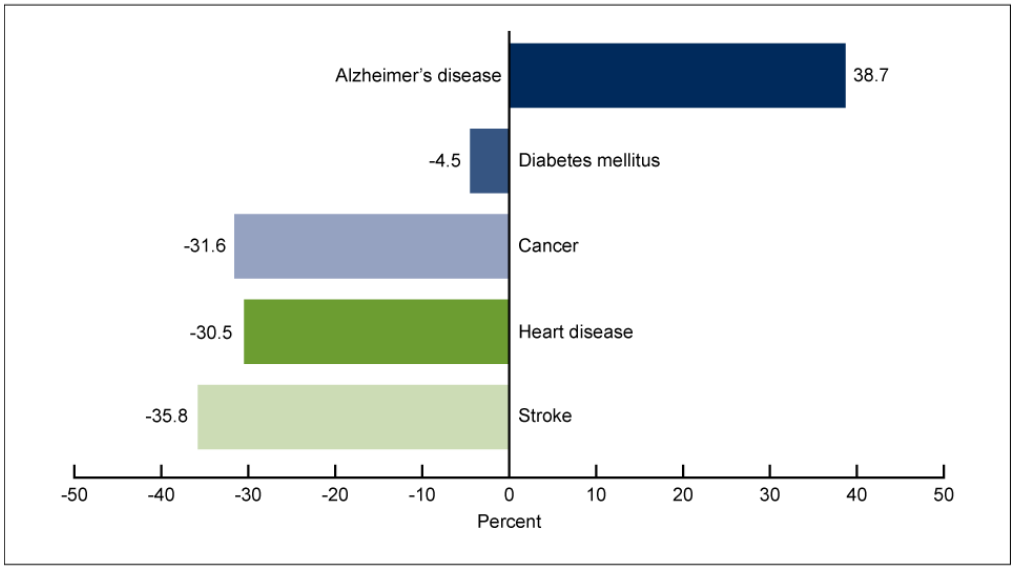
www/cancer.org

Deaths attributable to cardiovascular disease (United States: 1900–2011).

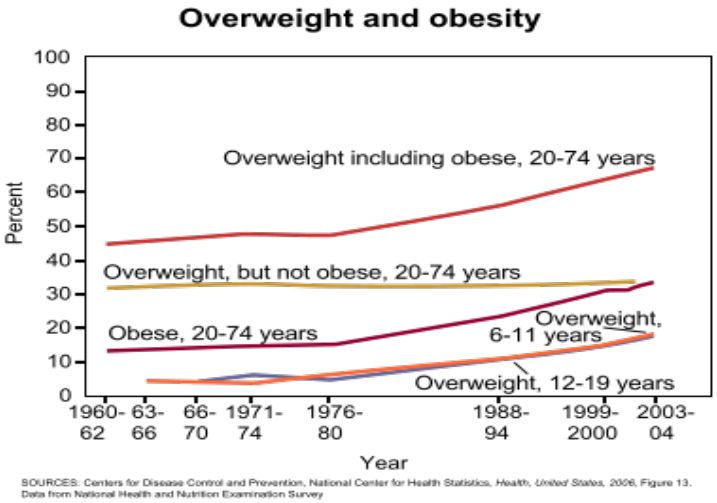
American Heart Association.

Mozaffarian D et al. Circulation. 2015;131:e29-e322

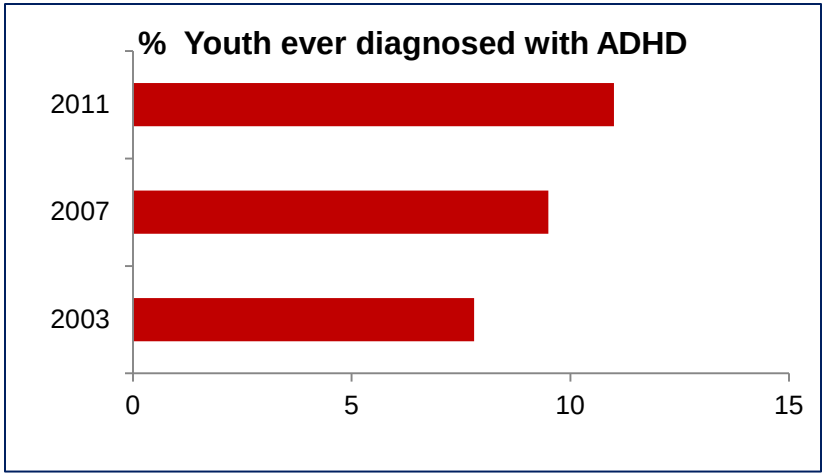
Figure 1. Percent change in age-adjusted death rates for selected causes of death: United States, 2000 and 2010



SOURCE: National Vital Statistics System, Mortality.



SOURCES: Centers for Disease Control and Prevention, National Center for Health Statistics, *Health, United States, 2006*, Figure 13. Data from National Health and Nutrition Examination Survey



www.CDC.org

Confounding issues

- GMO crops linked with pesticides, specifically glyphosate
- No scientific evidence linking glyphosate to disease

- Review of literature found no plausible mechanism by which glyphosate would induce adverse developmental or reproductive outcomes
  - Williams et al. J Tox Envir Health 15:39-96, 2012
- Animal studies found not risk for cardiovascular defects from glyphosate exposure during pregnancy
  - Kimmel et al. Crit Rev Tox 43:79-95, 2013
- Meta-analysis found no relationship between cancer and glyphosate exposure
  - Mink et al. Reg Tox Pharm 63:440-452, 2012

Scientific review

- Center for Science in the Public Interest
  - *"…there is strong international consensus from both scientific regulatory bodies…, as well as scientific societies…..that foods made from the current GE crops are safe to eat."* *Gregory Jaffe*

- American Association for the Advancement of Science
  - *"The World Health Organization, the American Medical Association, the U.S. National Academy of Sciences, the British Royal Society, and every other respected organization that has examined the evidence has come to the same conclusion: consuming foods containing ingredients derived from GM crops is no riskier than consuming the same foods containing ingredients from crop plants modified by conventional plant improvement techniques."*

http://cspinet.org/images/maygregfpd.pdf

Statement by the AAAS Board of Directors on Labeling of Genetically Modified Foods, 20 October 2012

Summary

- GMO technology
  - Provides important tools for modern food system
  - No scientific basis for risk to human or animal health
  - Should be continually monitored and evaluated
  - Safety assessment must be transparent