Associations of processed meat and unprocessed red meat intake with incident diabetes: the Strong Heart Family Study

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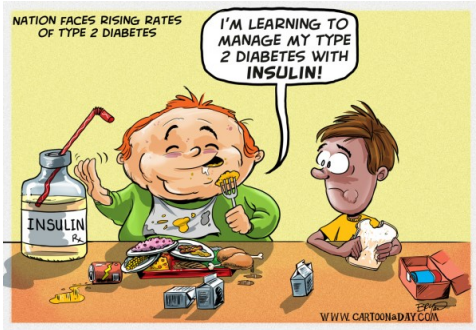
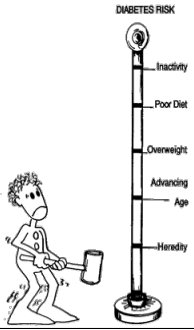
What is diabetes?



Key Terms

• Type 1 diabetes	Pancreas doesn't make enough insulin (injections)
• Type 2 diabetes	Results from a combination of resistance to the action of insulin and insufficient insulin production
• Hyper/hypoglycemia	High or low blood sugar
• A1C	A test that measures a person's average blood glucose level

Who is at Risk?



Diabetes Diagnosis

- **Current criteria for the diagnosis of diabetes (2012)**

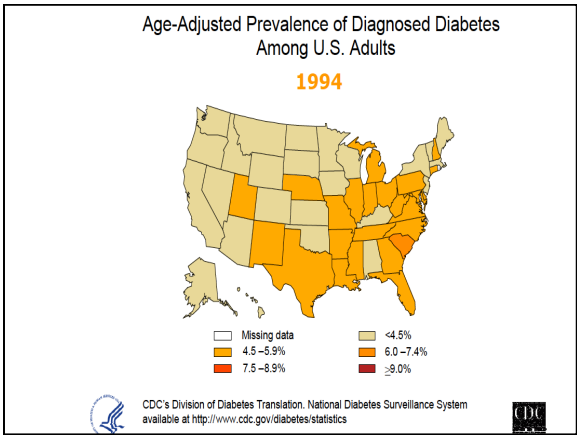
- A1C ≥6.5%. or
- fasting plasma glucose (FPG) ≥126 mg/dL or
- 2-h plasma glucose ≥200 mg/dL (11.1 mmol/l) during an oral glucose tolerance test (OGTT). or
- in a patient with classic symptoms of hyperglycemia or hyperglycemic crisis, a random plasma glucose ≥200 mg/dL (11.1 mmol/l); or
- in the absence of unequivocal hyperglycemia

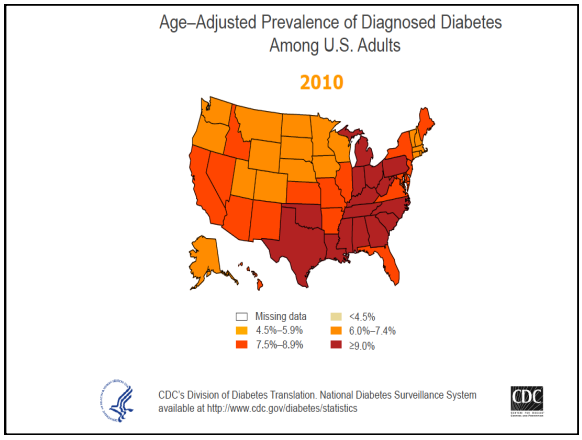
American Diabetes Association

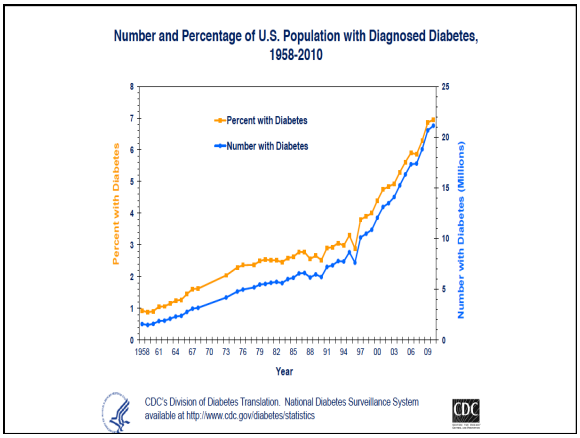
2010 Dietary Guidelines

- <u>Diet- related chronic diseases: Diabetes</u>
  - Nearly 24 million people, almost 11% of the population, ages 20 years and older have diabetes
  - Majority of cases are Type 2 diabetes, which is heavily influenced by diet and physical activity

- Processed meat is not emphasized in guidelines







American Indians & Diabetes

- **2.2 times higher**- Likelihood of AI to have diabetes compared with non-Hispanic whites
- **68%**- Percent increase in diabetes from 1994 to 2004 in AI youth aged 15-19 years
- **95%-** Percent of AI with diabetes who have type 2
- *One tribe in Arizona has the highest rate of diabetes in the world→ About 50% of the tribe between the ages of 30 and 64 have diabetes*

Why?

- Many factors contribute to these huge increases!
  - Moving away from traditional lifestyles
  - Westernized diets
  - Low physical activity
  - Genetics

U.S. Department of Health and Human Services

Sodium & Diabetes

- American Diabetes Association Guidelines: Recommends people with diabetes have 2,300 mg or less/day
  - It is estimated that about 75% or more of the sodium individuals eat is from processed, packaged foods
- Connection to diabetes:
  - Processed meats are high in additives such as sodium nitrate, which may influence diabetes risk
  - The heating and processing of meats has been shown to influence inflammation and oxidative stress (risk factors)

American Indians, Spam, & Diabetes

55% of AI develop diabetes by age 55

Many AI have limited access to healthy foods living in rural areas or on reservations

AI consume high intakes of processed meat, especially spam

What is the association of intake of processed meat with incident of diabetes among AI?

Purpose

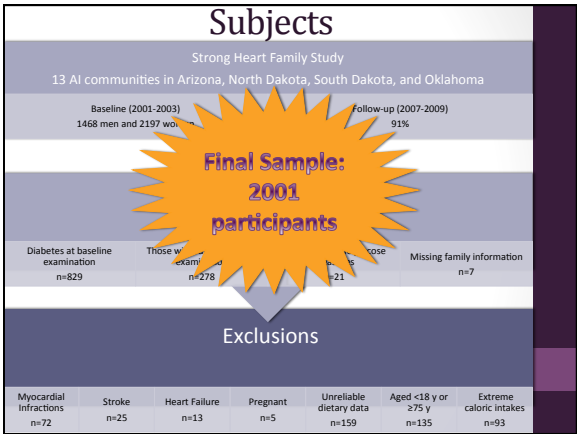
- Need for research→ prior studies have not examined the associations of processed meat or unprocessed red meat intake among populations with very high rates of obesity and diabetes
- Objective: To examine the associations of usual intake of processed meat and unprocessed red meat with incident of diabetes among American Indians participating in the Strong Heart Family Study
- Hypothesis: The health effects of meat intake on diabetes risk may differ by type of meat (i.e. processed meat or unprocessed meat)

Study Design

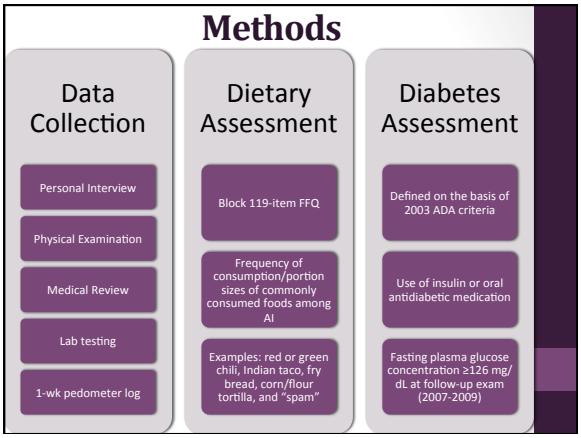
- Study Design: Prospective cohort study
- Dependent Variable: Incident of diabetes
- Independent Variable: Processed meat vs. Unprocessed red meat
- Instruments:

- **Block food-frequency questionnaire** to measure food intake during the past year

Subjects



Methods



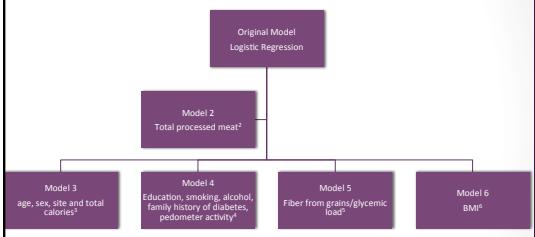
Statistical Analyses

- **Generalized Estimating Equations (GEE)**
  - GEE is a method of analyzing correlated data
    - "Clustering": measurements are taken on subjects who share a common characteristic (familial clustering)
  - Used a binary logistic model
    - Used to examine the associations of dietary intake with incident diabetes

Processed meat → breakfast sausage, spam, hot dogs and lunch meat

Unprocessed meat → pork chops, pork roast, dinner ham, veal, lamb, deer, ribs, hamburger, cheeseburger, roast beef, steak, and liver

Models



Results

TABLE 1
Baseline characteristics of study participants according to quartile of processed meat intake

Characteristics	Processed meat intake (g/1000 kcal) <6.5	6.5 to <11.4	11.4 to <18.2	≥18.2
Age (y)	36.4 ± 16.0[1]	36.7 ± 14.3	34.1 ± 13.7	32.9 ± 12.8
Female (%)	76.6	63.6	53.2	50.8
Waist circumference (cm)	97.4 ± 16.0	101.6 ± 17.8	103.5 ± 18.5	104.5 ± 18.4
BMI (kg/m^2)	30.2 ± 6.9	31.6 ± 7.5	32.1 ± 7.8	32.3 ± 8.2
SBP[2] (mm Hg)	119.0 ± 15.2	120.3 ± 14.1	120.2 ± 14.3	120.7 ± 15.2
Insulin (μU/mL)	15.6 ± 17.8	15.3 ± 11.4	16.1 ± 14.8	16.8 ± 13.8
Fasting glucose (mg/dL)	92.0 ± 10.4	94.4 ± 10.1	94.2 ± 10.8	94.7 ± 10.5
HDL cholesterol (mg/dL)	53.5 ± 14.4	52.2 ± 15.1	51.1 ± 14.7	50.5 ± 14.0
Education (y)	12.4 ± 2.3	12.2 ± 2.2	11.7 ± 2.3	11.4 ± 2.1
Steps/d	6394.4 ± 3916.6	5854.9 ± 3652.6	6433.2 ± 4354.8	6195.2 ± 4043.2
Total fat (% of energy)	36.1 ± 7.9	37.9 ± 6.5	38.8 ± 6.1	40.8 ± 5.7
Saturated fat (% of energy)	10.6 ± 2.4	11.3 ± 1.9	11.7 ± 1.9	12.5 ± 1.8
Carbohydrates (% of energy)	52.2 ± 10.0	49.6 ± 7.8	47.7 ± 7.4	45.2 ± 7.0
Unprocessed red meat (g/1000 kcal)	21.8 ± 19.7	24.7 ± 16.5	22.3 ± 14.7	22.3 ± 14.4
Total dietary fiber (g/1000 kcal)	7.9 ± 3.0	7.4 ± 2.4	7.2 ± 2.0	6.7 ± 1.9
Fruit (servings/d)	1.1 ± 1.0	0.9 ± 0.8	0.9 ± 0.7	0.9 ± 0.7
Vegetables (servings/d)	2.6 ± 2.3	2.5 ± 2.0	2.6 ± 1.9	2.5 ± 2.3
Added sugar (mL)	119.5 ± 86.5	121.0 ± 84.5	123.0 ± 78.5	118.5 ± 79.5
Sweetened-beverage intake (%)				
<1 time/mo	10	7.7	5.8	4.0
1–8 times/mo	30.5	27.8	26.6	21.6
3–6 times/wk	24.0	34.8	41.8	39.4
Every day	35.5	29.8	25.8	25.0
Smoking (%)				
Never	47.1	43.8	42.8	40.4
Current	30.9	35.1	37.0	40.2

[1] Mean ± SD (all such values).
[2] SBP, systolic blood pressure.

Those with highest processed meat intake (including spam):
- Younger, wider waist circumference, and less educated
- Higher BMI, SBP, insulin, FBG, %fat, % sat. fat
- Lower HDL, CHO and fiber intake

TABLE 2
ORs (95% CIs) of diabetes according to processed meat intake[1]

	Quartile 1	2	3	4	*P*-trend
Processed meat intake (g/1000 kcal)[2]	<6.5	6.5 to <11.4	11.4 to <18.2	≥18.2	
Median intake (IQR)	3.71 (2.27, 5.03)	8.83 (7.57, 10.1)	14.5 (12.9, 15.9)	23.6 (20.8, 29.2)	
No. of cases	39	61	79	64	
Total no. at risk	501	500	500	500	
Model					
Minimally adjusted[3]	1.00	1.61 (1.03, 2.54)	2.01 (1.31, 3.09)	1.63 (1.04, 2.54)	0.03
Multivariate[4]	1.00	1.53 (0.96, 2.44)	1.96 (1.25, 3.06)	1.55 (0.97, 2.47)	0.04
Dietary factors[5]	1.00	1.56 (0.97, 2.49)	2.03 (1.28, 3.20)	1.63 (1.21, 2.63)	0.03
BMI[6]	1.00	1.45 (0.89, 2.35)	1.77 (1.10, 2.85)	1.35 (0.81, 2.25)	0.17
Spam intake (g/1000 kcal)	0	0.10 to <1.14	1.14 to <3.10	≥3.10	
Median intake (IQR)	0 (0, 0)	0.71 (0.51, 0.91)	1.83 (1.43, 2.35)	5.88 (4.15, 9.44)	
No. of cases	44	48	66	85	
Total no. at risk	579	422	500	500	
Model					
Minimally adjusted[3]	1.00	1.27 (0.83, 1.95)	1.49 (0.90, 2.47)	1.95 (1.24, 3.07)	0.001
Multivariate[4]	1.00	1.31 (0.83, 2.06)	1.52 (0.91, 2.52)	1.99 (1.25, 3.17)	0.001
Dietary factors[5]	1.00	1.31 (0.83, 2.07)	1.54 (0.92, 2.56)	2.06 (1.30, 3.27)	0.001
BMI[6]	1.00	1.37 (0.87, 2.15)	1.40 (0.82, 2.36)	1.86 (1.17, 2.95)	0.01

Risk of diabetes goes down when model is adjusted for BMI

	Quartile 1	2	3	4	*P*-trend
Processed meat intake (g/1000 kcal)[2]	<6.5	6.5 to <11.4	11.4 to <18.2	≥18.2	
Breakfast sausage intake (g/1000 kcal)	<0.74	0.74 to <2.08	2.08 to <4.57	4.57+	
Median intake (IQR)	0.31 (0, 0.52)	1.33 (1.02, 1.69)	3.02 (2.48, 3.65)	7.42 (5.71, 10.3)	
No. of cases	55	57	70	61	
Total no. at risk	501	500	500	500	
Model					
Minimally adjusted[3]	1.00	1.10 (0.75, 1.61)	1.42 (1.01, 2.01)	1.26 (0.86, 1.84)	0.15
Multivariate[4]	1.00	0.99 (0.67, 1.44)	1.30 (0.91, 1.86)	1.22 (0.82, 1.82)	0.21
Dietary factors[5]	1.00	1.00 (0.68, 1.46)	1.32 (0.93, 1.88)	1.24 (0.83, 1.86)	0.18
BMI[6]	1.00	0.87 (0.59, 1.28)	1.18 (0.80, 1.73)	1.09 (0.72, 2.66)	0.40
Hot dog intake (g/1000 kcal)	<0.90	0.90 to <2.06	2.06 to <4.13	≥4.13	
Median intake (IQR)	0.27 (0, 0.62)	1.45 (1.17, 1.76)	2.90 (2.42, 3.46)	6.57 (5.12, 10.0)	
No. of cases	56	67	62	58	
Total no. at risk	501	500	500	500	
Model					
Minimally adjusted[3]	1.00	1.20 (0.82, 1.77)	1.11 (0.78, 1.58)	1.08 (0.73, 1.61)	0.82
Multivariate[4]	1.00	1.21 (0.78, 1.85)	1.10 (0.75, 1.61)	1.06 (0.69, 1.63)	0.91
Dietary factors[5]	1.00	1.21 (0.79, 1.85)	1.11 (0.76, 1.62)	1.08 (0.70, 1.67)	0.83
BMI[6]	1.00	1.13 (0.74, 1.72)	0.97 (0.65, 1.44)	0.88 (0.56, 1.38)	0.43
Lunch meat intake (g/1000 kcal)	<0.92	0.92 to <2.51	2.51 to <5.57	≥5.57	
Median intake (IQR)	0 (0, 0.53)	1.61 (1.24, 2.03)	3.74 (3.13, 4.62)	8.61 (6.97, 11.7)	
No. of cases	54	64	52	73	
Total no. at risk	501	500	500	500	
Model					
Minimally adjusted[3]	1.00	1.16 (0.80, 1.68)	0.91 (0.63, 1.33)	1.39 (1.00, 1.95)	0.25
Multivariate[4]	1.00	1.11 (0.75, 1.62)	0.98 (0.67, 1.45)	1.42 (1.00, 2.01)	0.17
Dietary factors[5]	1.00	1.11 (0.75, 1.63)	1.00 (0.68, 1.46)	1.44 (1.01, 2.06)	0.14
BMI[6]	1.00	1.18 (0.80, 1.74)	0.91 (0.60, 1.37)	1.44 (0.98, 2.12)	0.20

There was no significant association of unprocessed red meats and diabetes risk

	Quartile 1	2	3	4	*P*-trend
Total unprocessed red meat (g/1000 kcal)[2]	<11.5	11.5 to <18.7	18.7 to <29.6	≥29.6	
Median intake (IQR)	8.08 (5.60, 9.89)	14.7 (13.2, 16.8)	23.2 (20.5, 26.1)	40.3 (34.3, 50.3)	
No. of cases	67	66	55	55	
Total no. at risk	501	500	500	500	
Model					
Minimally adjusted[3]	1.00	1.13 (0.80, 1.58)	0.94 (0.64, 1.39)	0.94 (0.64, 1.40)	0.49
Multivariate[4]	1.00	1.13 (0.78, 1.65)	0.92 (0.61, 1.40)	0.87 (0.58, 1.32)	0.32
Dietary factors[5]	1.00	1.14 (0.78, 1.65)	0.93 (0.61, 1.42)	0.90 (0.59, 1.37)	0.42
BMI[6]	1.00	1.12 (0.77, 1.64)	0.83 (0.54, 1.27)	0.88 (0.57, 1.35)	0.31
Hamburger/cheeseburger (g/1000 kcal)	<2.29	2.29 to <5.17	5.17 to <9.29	≥9.29	
Median intake (IQR)	1.64 (1.12, 2.13)	3.72 (3.15, 4.43)	7.01 (6.13, 8.10)	15.1 (12.0, 21.3)	
No. of cases	71	60	64	48	
Total no. at risk	501	500	500	500	
Model					
Minimally adjusted[3]	1.00	0.92 (0.62,1.37)	1.06 (0.74, 1.51)	0.79 (0.52, 1.19)	0.35
Multivariate[4]	1.00	0.90 (0.60, 1.36)	1.02 (0.73, 1.43)	0.74 (0.47, 1.16)	0.24
Dietary factors[5]	1.00	0.90 (0.60, 1.35)	1.02 (0.73, 1.43)	0.75 (0.48, 1.18)	0.27
BMI[6]	1.00	0.80 (0.52, 1.25)	0.93 (0.65, 1.33)	0.69 (0.43, 1.12)	0.18
Beef (g/1000 kcal)	<2.53	2.53 to <5.33	5.33 to <10.1	≥10.1	
Median intake (IQR)	1.36 (0.59, 1.87)	3.76 (3.13, 4.49)	7.24 (6.26, 8.45)	15.6 (12.4, 22.7)	
No. of cases	53	53	71	58	
Total no. at risk	501	500	500	500	
Model					
Minimally adjusted[3]	1.00	0.86 (0.53, 1.40)	1.21 (0.80, 1.83)	0.99 (0.66, 1.48)	0.71
Multivariate[4]	1.00	0.88 (0.54, 1.44)	1.28 (0.83, 1.98)	1.00 (0.65, 1.55)	0.6
Dietary factors[5]	1.00	0.89 (0.54, 1.44)	1.31 (0.84, 2.02)	1.05 (0.67, 1.64)	0.47
BMI[6]	1.00	0.83 (0.51, 1.35)	1.16 (0.76, 1.78)	0.93 (0.60, 1.44)	0.9
Pork (g/1000 kcal)	<1.68	1.68 to <3.67	3.67 to <7.12	≥7.12	
Median intake (IQR)	0.96 (0.40, 1.29)	2.67 (2.09, 3.19)	5.13 (4.33, 6.66)	10.5 (8.55, 14.4)	
No. of cases	53	61	62	67	
Total no. at risk	501	500	500	500	
Model					
Minimally adjusted[3]	1.00	1.18 (0.79, 1.77)	1.27 (0.88, 1.83)	1.33 (0.92, 1.94)	0.17
Multivariate[4]	1.00	1.21 (0.81, 1.81)	1.28 (0.87, 1.90)	1.21 (0.80, 1.84)	0.37
Dietary factors[5]	1.00	1.23 (0.82, 1.84)	1.30 (0.88, 1.92)	1.26 (0.83, 1.92)	0.3
BMI[6]	1.00	1.25 (0.84, 1.86)	1.23 (0.82, 1.86)	1.18 (0.77, 1.82)	0.45

Conclusions & Implications

- Intake of processed meats, specifically spam, is associated with a higher risk of developing diabetes
- In contrast, consumption of unprocessed red meat intake was not associated with diabetes development
- AI represent a population where a dietary intervention is needed to prevent diabetes

Limitations?

- FFQ- 1 year recall
- Model that adjusted for BMI may underestimate the effect of processed meat
- Sample was not diverse
- Lean meats such as chicken and turkey were not included in analysis
- The sample itself received free spam
- Did not confound for physical activity

Strengths?

- Documented history of diabetes
- Biomarkers for diabetes (fasting plasma glucose ≥126 mg/dL)
- Body composition
- Assessing AI population and processed meat intake/diabetes few have studied
- Used GEE to address familial correlation instead of simply a logistic model (take familial correlation into account to calculate the odds ratios)

Follow-up Study

- **Purpose:** To evaluate the single and joint effect of diet and exercise on those with diabetes

- Does increased physical activity and/or diet reverse the symptoms of diabetes

- **Study Design:** Randomized Controlled Trial
- 205 participants were recruited in CA by research team (100 men and 105 women)
- Participants were randomized to either the control group, diet group, exercise group, or diet and exercise group

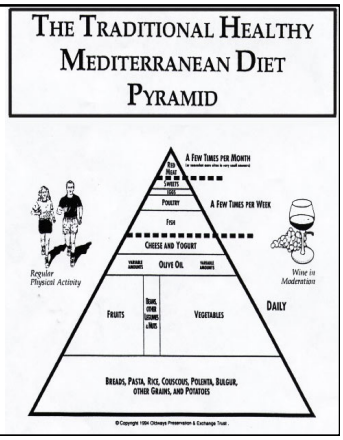
- **Subjects:**
  - Preexisting diabetes (type 2)
  - Ethnically diverse sample aged 40-65 years old
  - Inclusion criteria: relatively inactive, high cholesterol, BMI, TG, fasting blood glucose
  - Exclusion criteria (confounders): alcohol, smoking, supplement use, other medical conditions
  - Dependent variable: diagnosis components of diabetes & symptoms (FBG, blood pressure, HDL chol., TG, total chol., BMI)
  - Independent variable: diet and exercise

- **Data Collection (1 year)**
  - Baseline and follow-up every three months
  - Biomarkers: fasting blood glucose
  - Blood sample: cholesterol panel including HDL, LDL, TG
  - Anthropometric measurements, BMI, and blood pressure

- **Dietary Assessment**:
  - FFQ

- **Intervention:**
  - Diet: Mediterranean diet
  - Exercise: cardio exercise activities 3 times/week

- **Statistical Analysis**:
  - MANOVA
  - Test for interaction between diet and exercise and for overall differences between groups for all four groups
  - T tests to evaluate pre and post changes



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