

# The Continuing Significance of Obesity for Survival to Old Age: A Re-Examination of Age Effect on the Body Weight-Mortality Relationship

Yan Yu

Department of Sociology  
University of Wisconsin - Madison

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# Question: Does the Weight-Mortality Link Vary by Age?

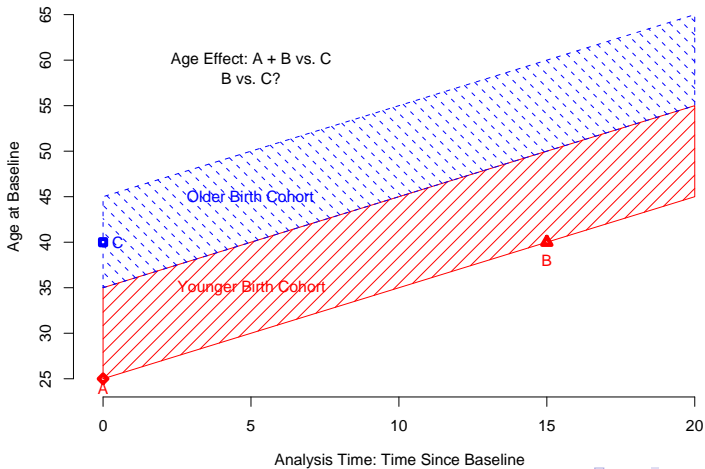
- Significance
  1. Optimal Weight management
  2. Age-specific weight guidelines
- Two contrasting hypotheses
  1. Age-as-leveler
    - Changes in the effect of body fat
    - Co-morbidities and short span
    - Weight change
    - Mortality selection
  2. Cumulative disadvantage: Permanent scarring
- Measure of mortality differentials: Mortality ratio

## Previous Studies: Findings and Limitations

- Findings: Inconsistent but leaning toward a diminishing effect (e.g., Stevens et al. 1998; Bender et al. 1999; Visscher et al. 2000)
- Limitations:
  1. Comparison of baseline age groups: Cohort effect
    - Cohort variations in BMI mortality differentials may distort age variations because at one given time, different cohorts are at different age.
  2. Outcome not age-specific: Age overlapping in age groups

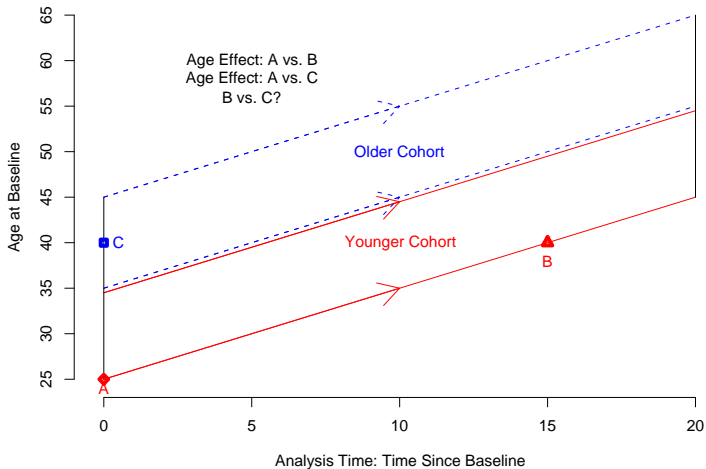
# Previous Studies: Time since Baseline as Analysis Time

Compare Baseline Age groups



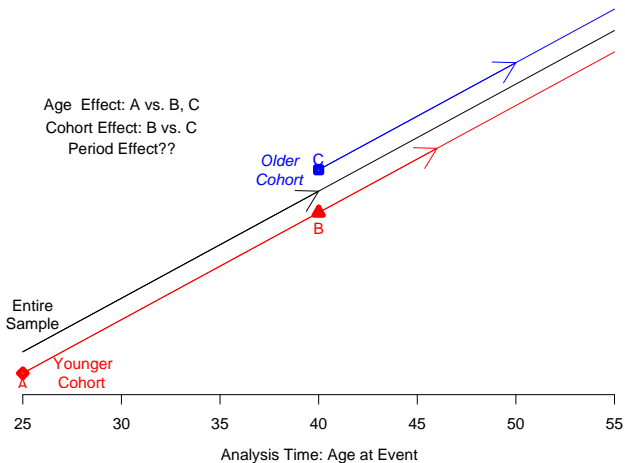
# Previous Studies: Time since Baseline as Analysis Time

Compare Points of Time in Follow-up



# This Study: Age as Analysis Time

## Compare Age-Specific BMI Differentials within Cohorts



## Data: 1971-1975 NHANES I

- National Health and Nutrition Examination Survey:  
Representative of non-institutionalized US population
- A sub-sample of those aged 24-77 at baseline: medical examination, with height and weight measured
- Mortality through 1992
- Body Mass Index (BMI):  $kg/m^2$
- Baseline BMI groups: WHO guidelines
  - Underweight (BMI < 18.5): excluded in the analysis
  - Normal weight ( $18.5 \leq \text{BMI} < 25$ ): reference category
  - Overweight ( $25 \leq \text{BMI} < 30$ )
  - Obese (BMI  $\geq 30$ )

# Data: NHANES I, Sample Selections

- Total: 14407 cases
- Deletions: 1035 cases
  - Immediately lost after baseline: 546 cases
  - Missing baseline BMI: 5 cases
  - Baseline underweight: 484 cases
- Analytic Sample: 5496 men and 7876 women
- Five birth cohorts:
  - 1895-1904
  - 1905-1914
  - 1915-1924
  - 1925-1934
  - 1935-1950



## Methods: Gompertz Model

- Baseline:  $h(a) = \exp(\beta + \gamma a)$
- BMI effect on  $\beta$  only: No Age variations

$$\beta = \beta_0 + \beta_1 W$$

- BMI effect on  $\beta$  and  $\gamma$ : Age variations

$$\begin{aligned}\beta &= \beta_0 + \beta_1 W \\ \gamma &= \gamma_0 + \gamma_1 W.\end{aligned}$$

- Cohort-BMI interaction: Cohort variations

$$\begin{aligned}\beta &= \beta_0 + \beta_1 W + \beta_2 C + \beta_3 WC \\ \gamma &= \gamma_0 + \gamma_1 W + \gamma_2 C + \gamma_3 WC.\end{aligned}$$

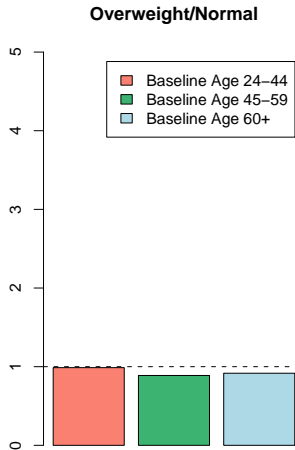
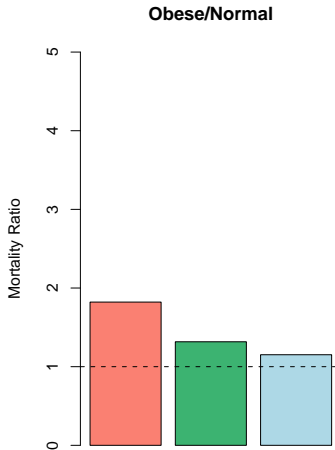
# Methods: Cont'd

## Frailty, Model Selection, and Robustness

- Gompertz with Frailty:  $h(a) = \alpha \exp(\beta + \gamma a)$ 
  - $\alpha$ : Mean 1 and variance  $\theta$ 
    1. Gamma distribution
    2. Inverse-Gaussian Distribution
- Analytic Strategy: The simplest model that fits the data best
  - The AIC criteria
- Semi-parametric Cox model

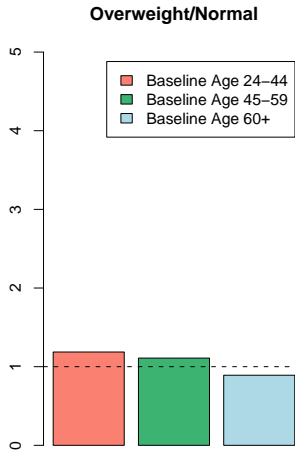
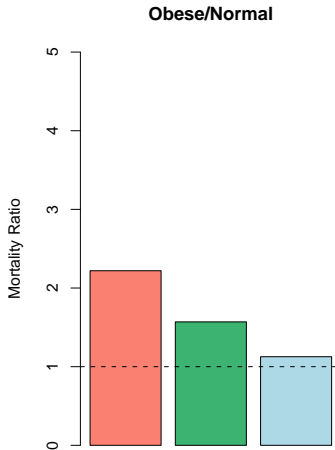
# For the Sake of Replication

Compare Baseline Age Group: Men

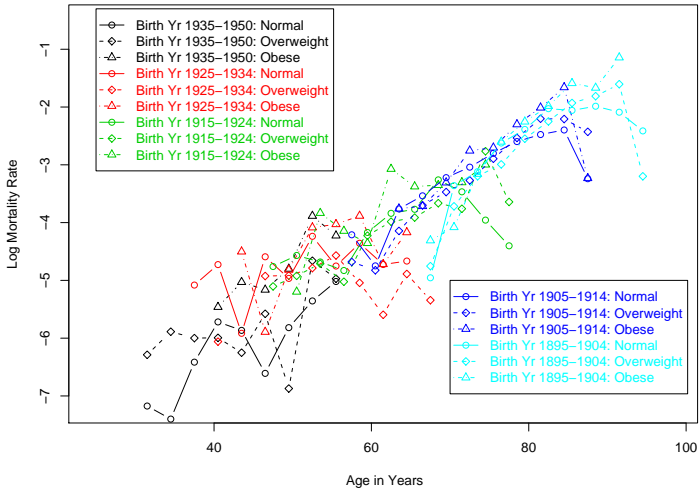


# For the Sake of Replication

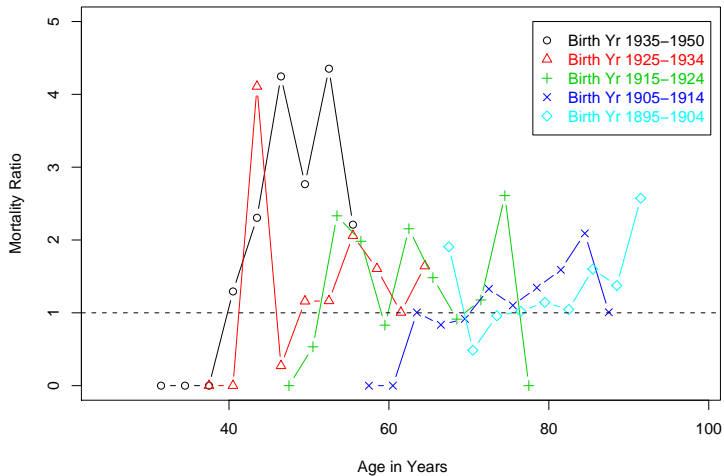
Compare Baseline Age Group: Women



# Results for Men: Mortality by Baseline BMI and Cohort

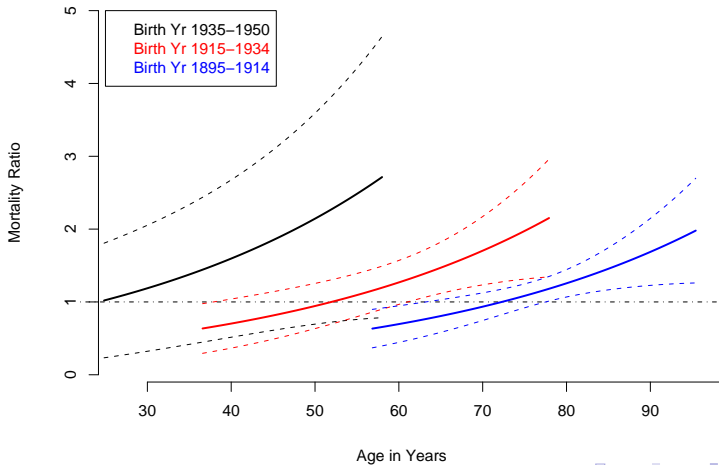


# Results for Men: Mortality Ratio, Baseline Obese/Normal



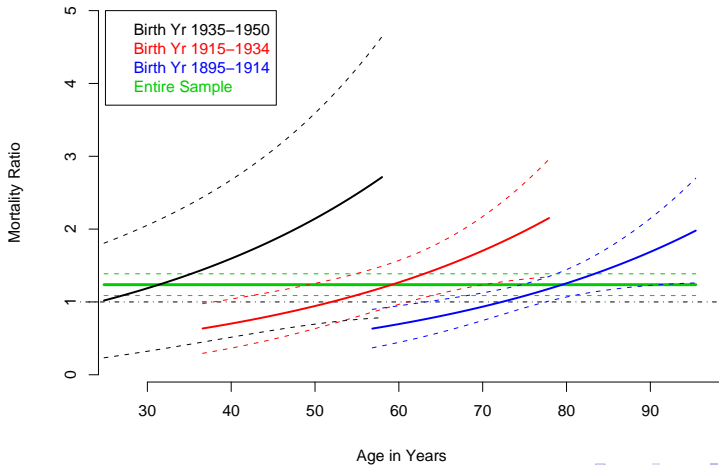
# Results for Men: Estimated Ratio and 95% C.I.

## Baseline Obese/Normal



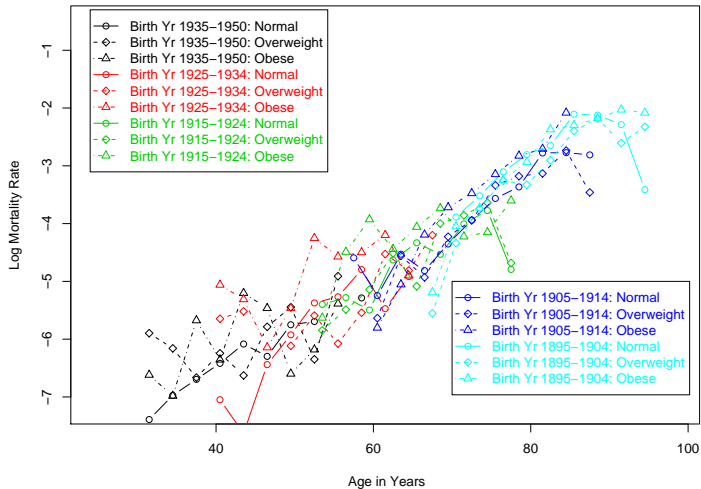
# Results for Men: Estimated Ratio and 95% C.I.

## Baseline Obese/Normal

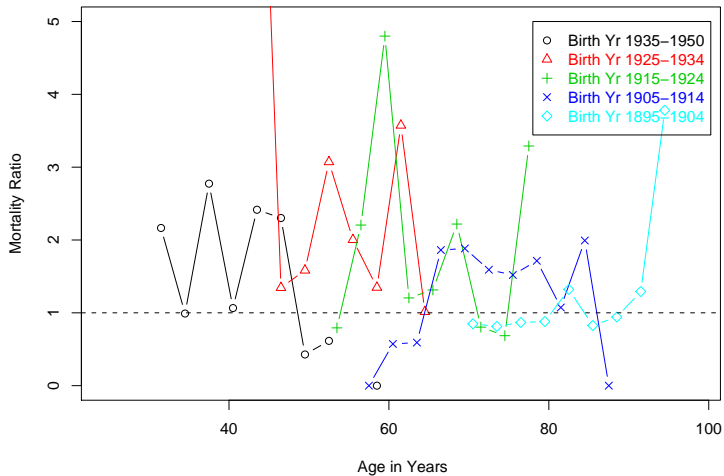




# Results for Women: Mortality by Baseline BMI and Cohort

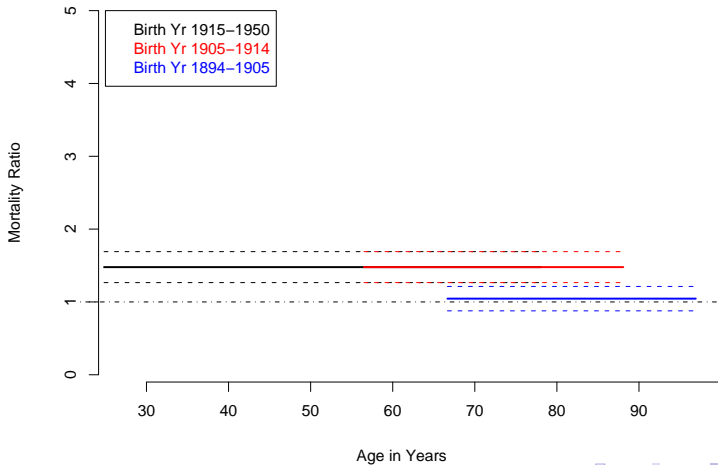


# Results for Women: Mortality Ratio, Obese/Normal



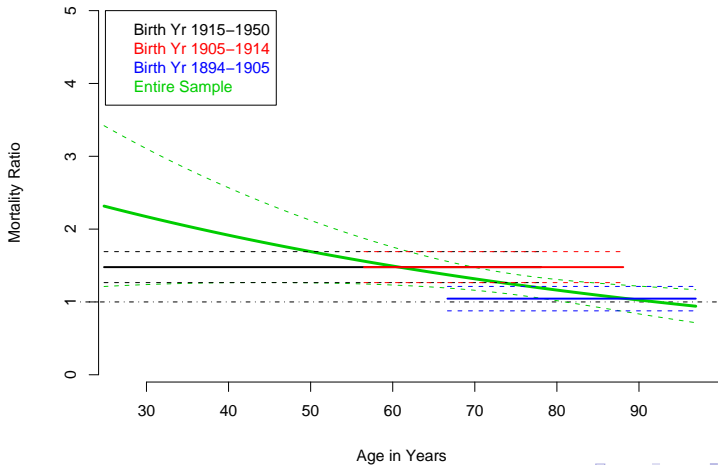
# Results for Women: Estimated Ratio and 95% C.I.

## Baseline Obese/Normal



# Results for Women: Estimated Ratio and 95% C.I.

## Baseline Obese/Normal



# Discussions

- Findings
  1. Age variations: Supportive of cumulative disadvantage
    - Men: Increase by age
    - Women: Constant
  2. Cohort variations: Increase from earlier to later cohorts
    - Implication for age variations
- Next steps
  1. Contribution of disease composition to age patterns
  2. Cohort changes:
    - Temporal changes as discussed in Su 2005 and Flegal et al. 2005
    - Body weight as more salient risk factor?
    - Health selection changed over time?
    - Weight change: Weight Measured at different ages?
  3. Analytic issues:
    - Smoking behavior
    - Early deaths: How many years of death should we delete?
    - Sample size: NHANES II