

Mortality Improvement

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SEAC Annual Meeting 11/19/09



Mortality Improvement



Recent Mortality Trends

- *By age & sex*
 - *US population*
 - *Insured lives*
- *By cause*

Risk Factor Trends

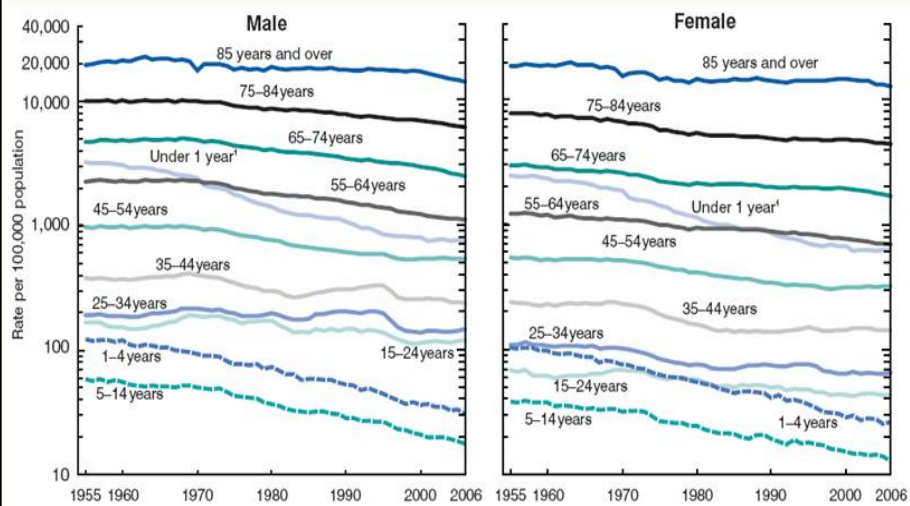
Estimating future improvement

- *Reasons for pessimism*
- *Reasons for optimism*
- *Methods*

Modeling US Population Mortality Trends



US Mortality Trends by Age & Sex 1955 - 2006



¹Death rates for "Under 1 year" (based on population estimates) differ from infant mortality rates (based on live births); see Figure 7 for infant mortality rates and "Technical Notes" for further discussion of the difference.
SOURCE: CDC/NCHS, National Vital Statistics System, Mortality Statistics Branch.

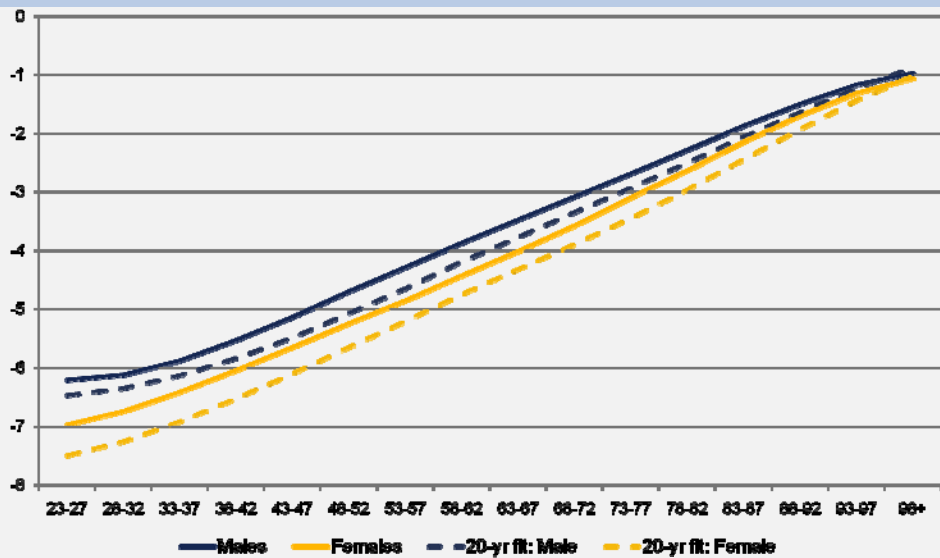
Lee-Carter Model

$$\ln(m(x, t)) = \alpha(x) + \beta(x) \cdot \kappa(t)$$

Where

- $m(x, t)$ = central death rate for age x, year t
- $\alpha(x)$ = average log death rate for age x
- $\kappa(t)$ = mortality level at year t
- $\beta(x)$ = sensitivity of mortality at age x to level changes

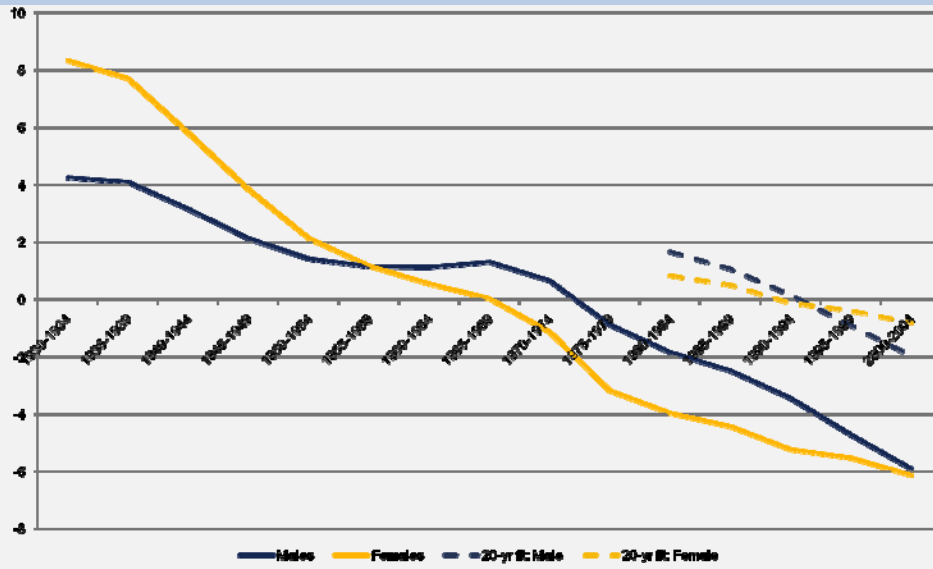
Lee-Carter Fit to US Population Mortality Average Logarithm of Death Rate



Lee-Carter Fit to US Population

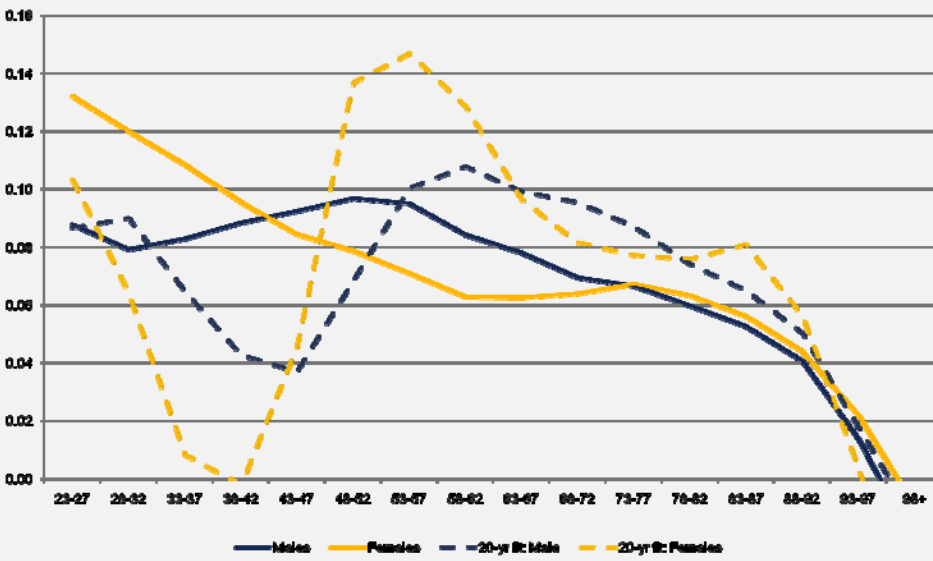


Mortality Time Trends



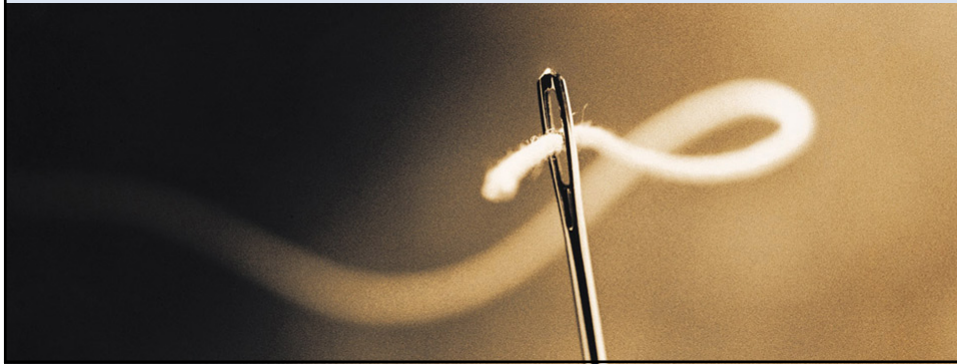
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Lee-Carter Fit to US Population Mortality Sensitivity by Age

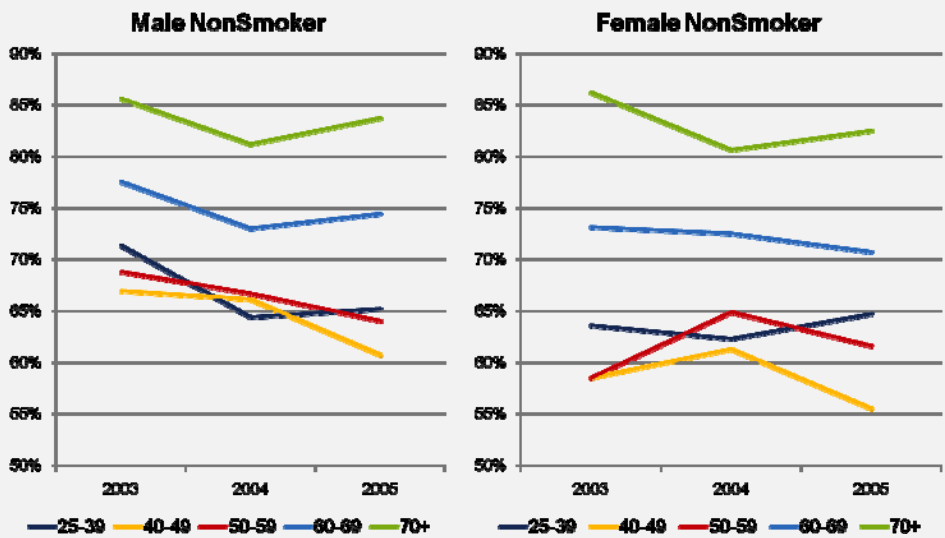


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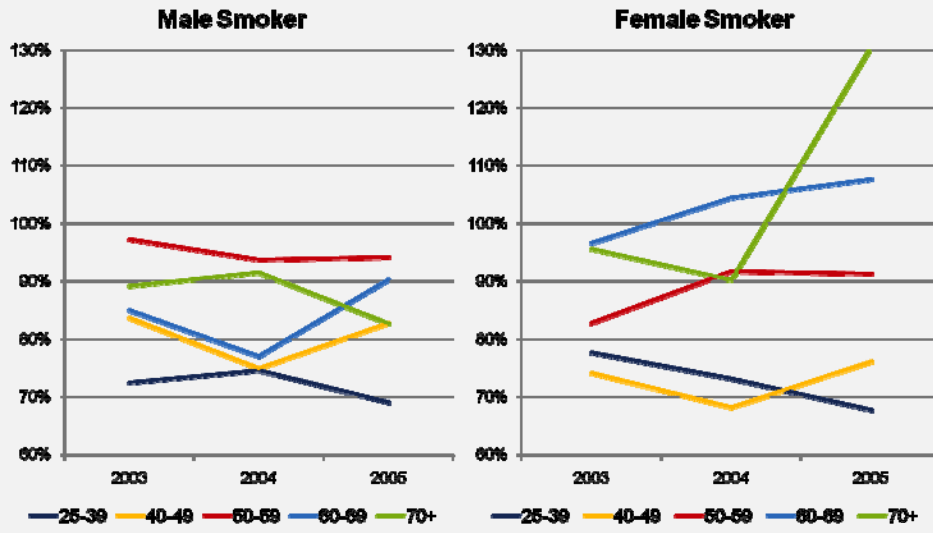
Insured Mortality Trends



SoA ILEC 2004-05 Study A/E vs 01 VBT by Count Select Durations 1 - 25 by Issue Age Band

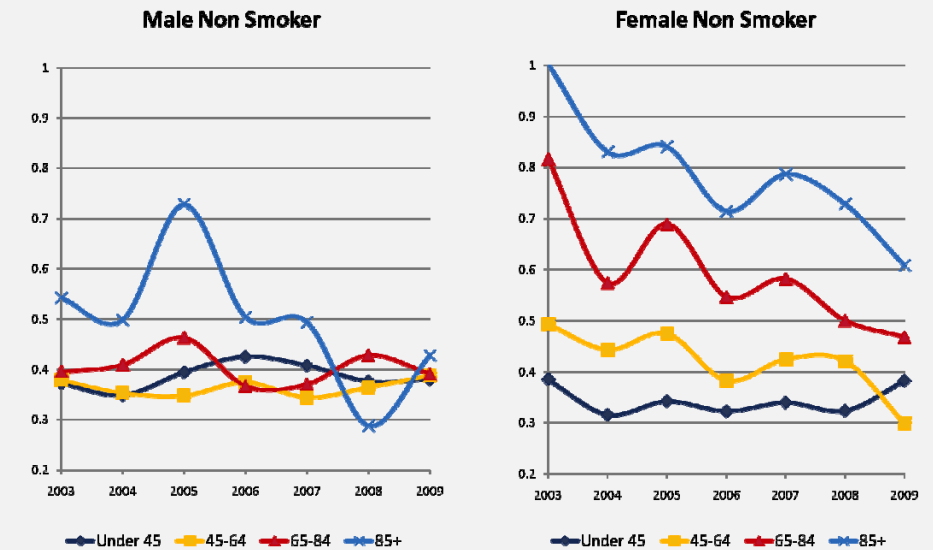


SoA ILEC 2004-05 Study
A/E vs 01 VBT by Count
Select Durations 1 - 25 by Issue Age Band



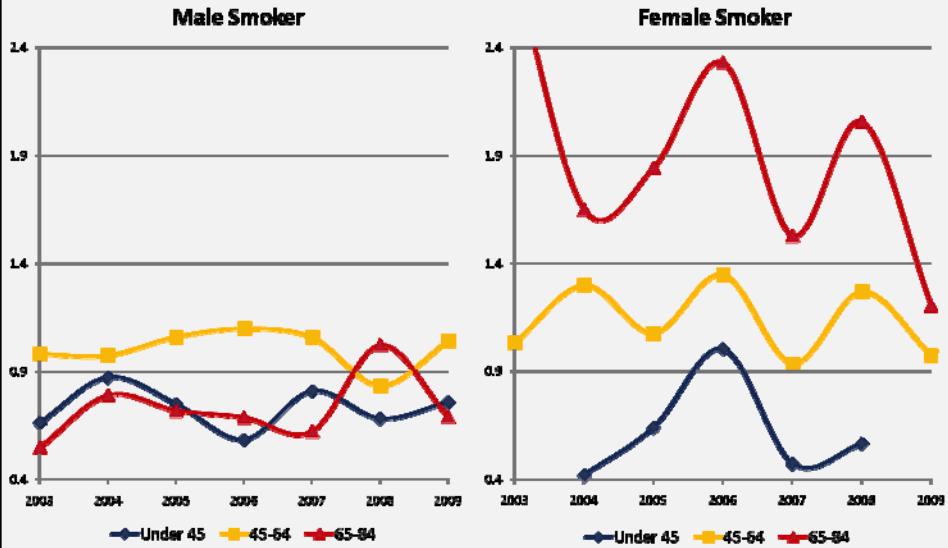
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MARC Mortality Study 2003-09
A/E vs 75-80 by Amount
Durations 1-15 by Attained Age Group



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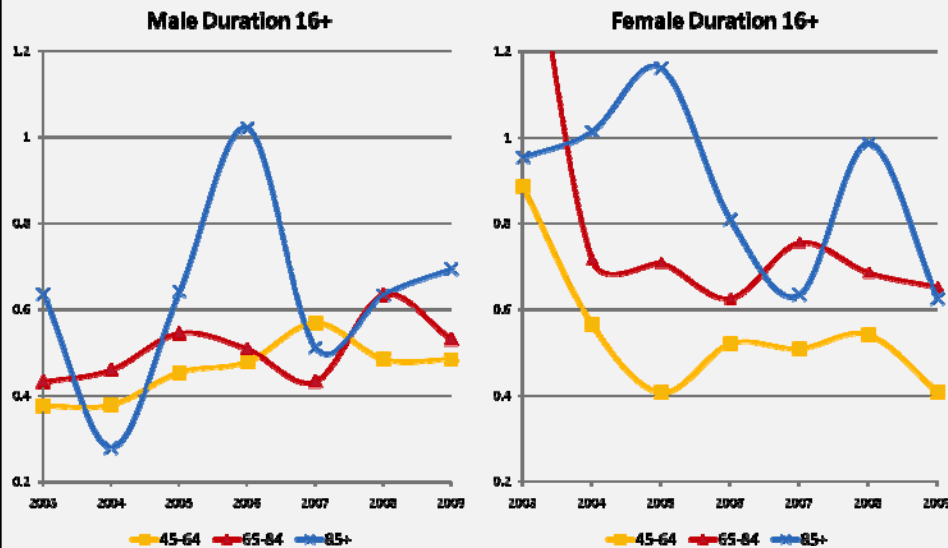
MARC Mortality Study 2003-09
A/E vs 75-80 by Amount
Durations 1-15 by Attained Age Group



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MARC Mortality Study 2003-09
A/E vs 75-80 by Attained Age Group
Aggregate Smoker Status



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$$\ln(\mu^I(x, t)) = \theta_1 + \theta_2 \cdot \ln(\mu^P(x, t))$$

and
$$\ln(\mu^P(x, t)) = \alpha(x) + \beta(x) \cdot \kappa(t)$$

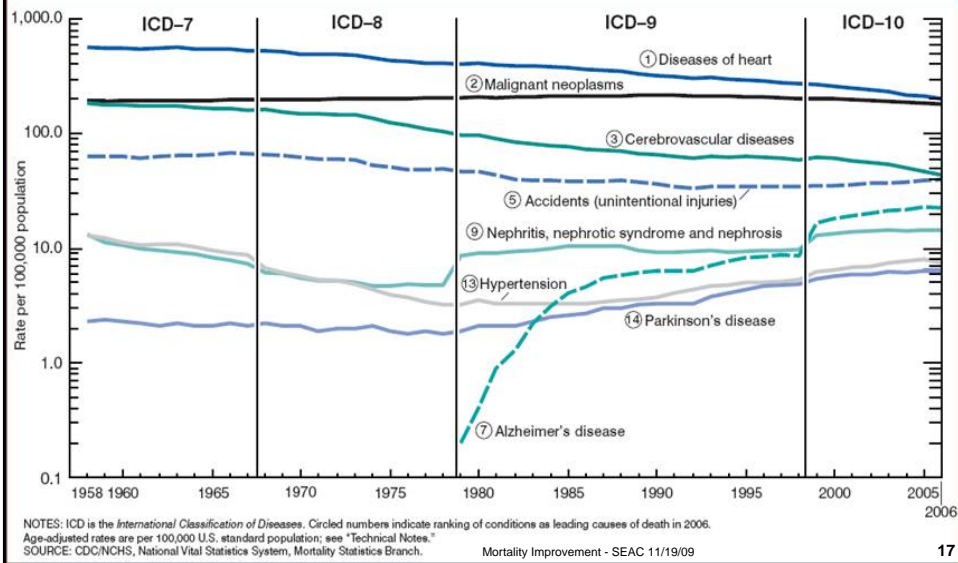
Where

- $\mu^I(x, t)$ = force of insured lives mortality for age x, year t
- $\mu^P(x, t)$ = force of population mortality for age x, year t
- θ_1, θ_2 are regression parameters
- $\alpha(x), \beta(x), \kappa(t)$ are the Lee-Carter vectors
- Fit assumes deaths are Poisson distributed

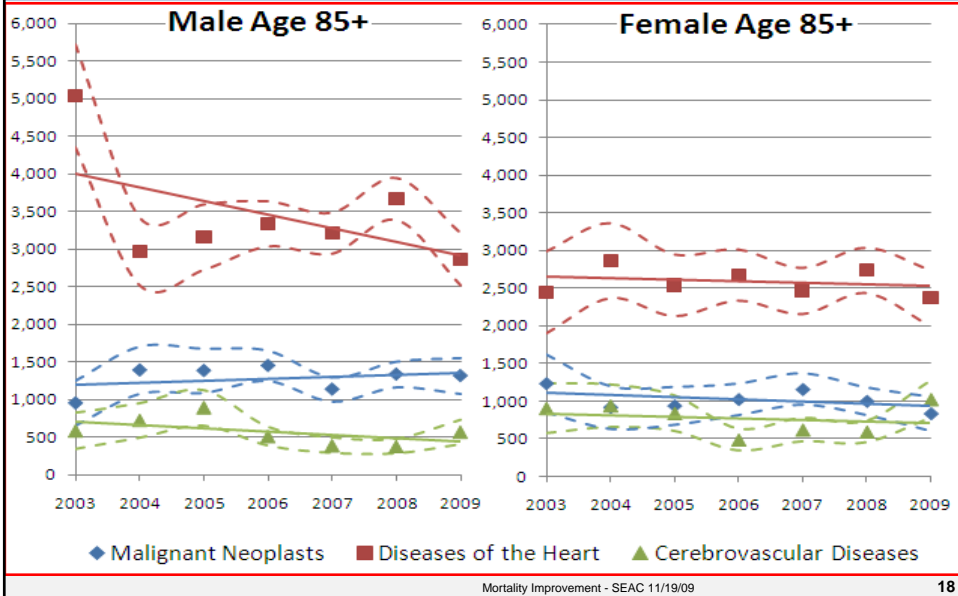
Recent Trends by Cause of Death



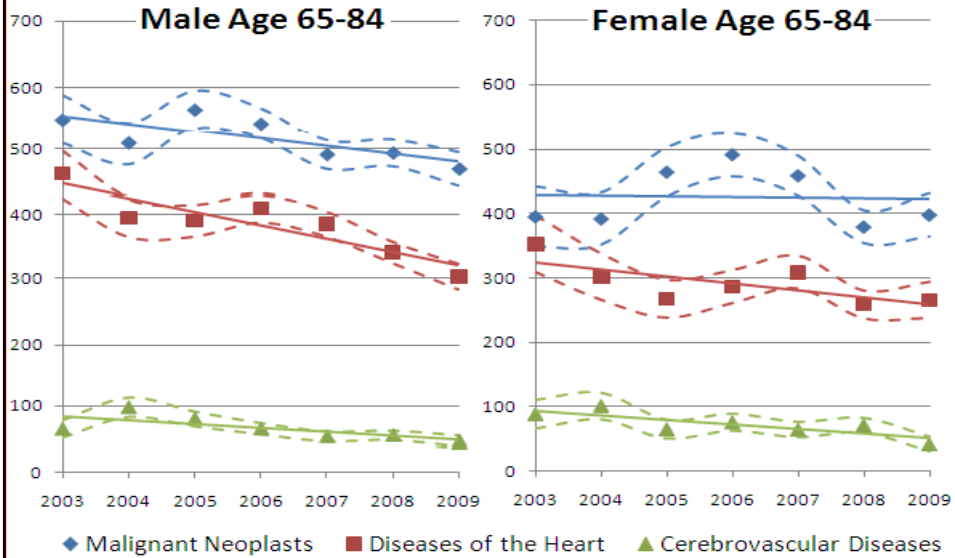
US Mortality Trends by Cause of Death Category



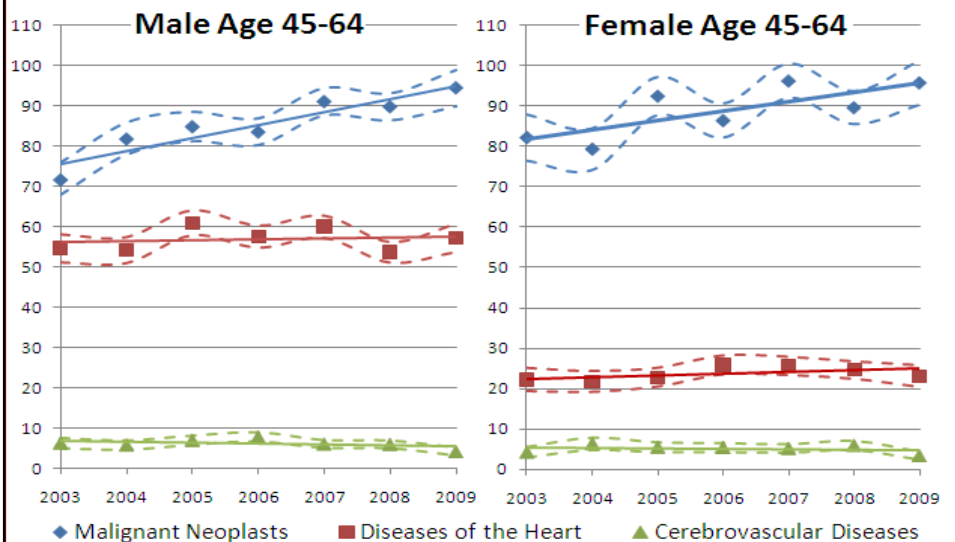
MARC Mortality Study 2003-09 Top 3 Causes of Death by Attained Age Group Crude Death Rates per 100,000



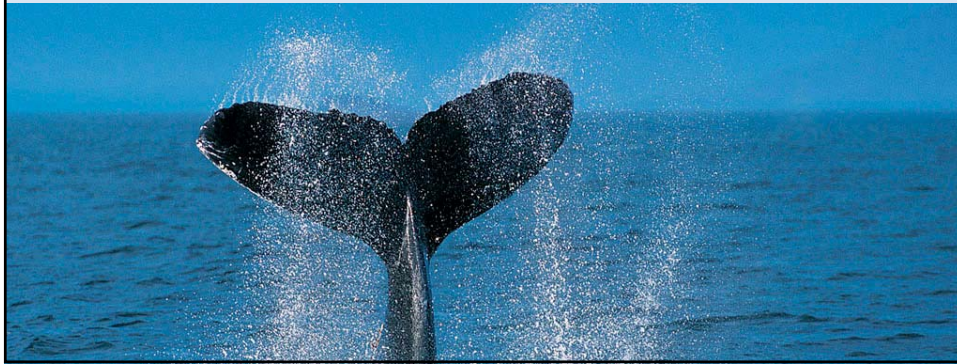
MARC Mortality Study 2003-09
Top 3 Causes of Death by Attained Age Group
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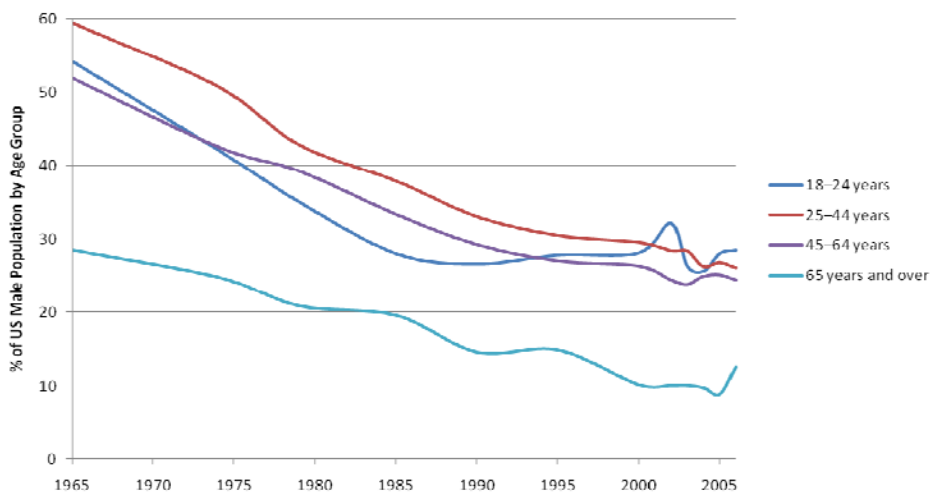


US Risk Factor Trends



US Risk Factor Trends

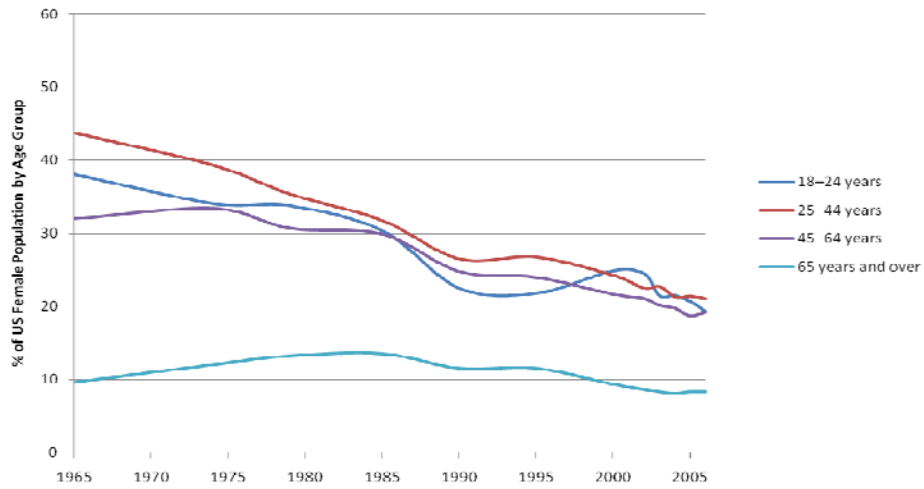
Cigarette Smoking Males 1965-2006



US Risk Factor Trends



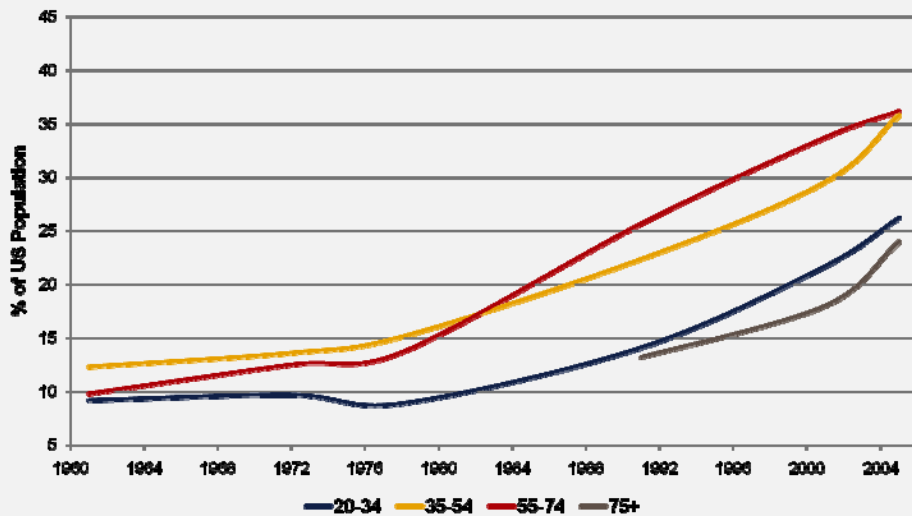
Cigarette Smoking Females 1965-2006



US Risk Factor Trends

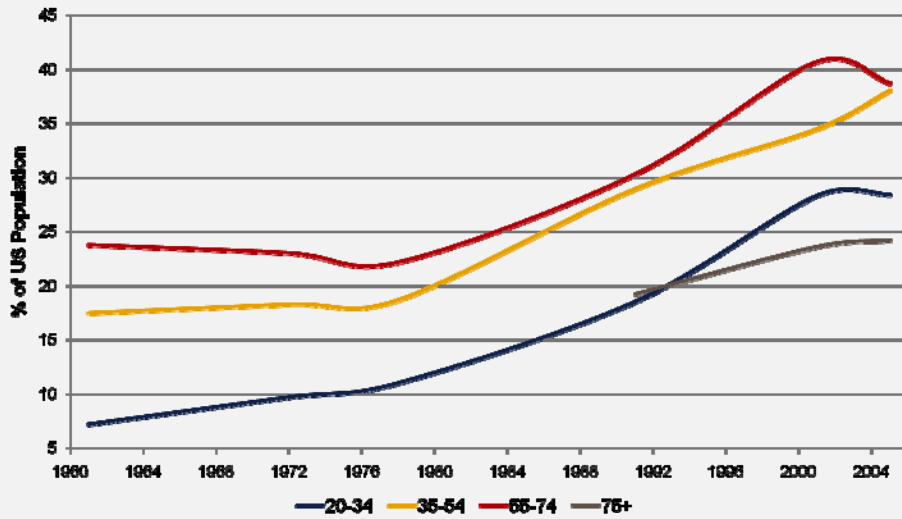


Male Obesity 1960 - 2006



US Risk Factor Trends

Female Obesity 1960-2006



Estimating Future Improvement



Reasons for Pessimism

- Sedentary lifestyles
- Rise in obesity
- End of decrease in smoking
- High cost of health care
- Distracted driving

Reasons for Optimism - Population

- Medical advances
 - Earlier disease detection & intervention
 - Biologics – monoclonal antibodies
 - Gene therapies
 - Nanomedicine
- Other research
 - Anti-aging: antioxidants, resveratrol, sirtuins, caloric restriction
 - Blue Zones
- Motivation & Resources

Reasons for Optimism - Insurance

- Better understanding of risk factors
 - Better underwriting tools
- Insurance applicants generally more affluent
 - Better access to health care
 - Better informed about risk factors

Methods for Projecting Mortality Improvement

- Extrapolation
 - Extend log-linear regressions by age
 - Forecast Lee-Carter $K(t)$
 - Random walk with drift
 - Choose fit & projection periods judiciously
 - Deterministic or Stochastic
- Expert Opinion
 - Predict progress against leading death causes
- Multi-state model

Current Mortality Improvement Research



- UK Continuous Mortality Investigation Projection Model
 - Initial improvement rates
 - Ultimate improvement rates
 - Speed and pattern of convergence
- SoA Reinsurance Section Research Project

Questions?

