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BLOOMBERG  
SCHOOL of PUBLIC HEALTH

# JHU Clinical Experts Forecast of USA Mortality from 2009 to 2040

Vladimir Canudas-Romo, Eva DuGoff, Albert Wu,  
Saifuddin Ahmed, Gerard Anderson

*Johns Hopkins Bloomberg School of Public Health*

# Motivation

- All projections of life expectancy require assumptions about future mortality levels.
- Expert panels of actuaries and/or demographers have been the primary experts consulted for future mortality trends.
- They represent two different disciplines.
- **What about a third approach?**

# Who we are not!

- We are not actuaries and only one member of our team is a demographer
- We were asked to look at trends in life expectancy based on clinical factors
- What diseases have been responsible for the increases in life expectancy in the past
- What improvements in public health and medicine are likely to be responsible for the increases in life expectancy in the future?

# We Offer A Sensitivity Analysis

- What information can public health and clinical experts tell us about possible changes in life expectancy?
- This approach provides two things
  - Sensitivity analysis – another method to answer the same question
  - A rationale for the projections aside from trend analysis
    - What clinical and public health factors will be responsible for increases in life expectancy?

# Our main concern

- We are assuming that improvements in public health and medical care are responsible for the increases in life expectancy
- Looking just at medical factors represents an incomplete model since other factors are clearly important
- We are aware and endorse the socioeconomic determinants of health literature
- However, death is caused by either illness or injury and so looking at the causes of death could make some sense
- We are not claiming that factors such as improvements in economic status are unimportant, but simply saying that we are looking at how they play out through specific causes of death

# My second concern

- Public health and medical school professors will be overly optimistic in what can be achieved in the future since that is their life work
- They are not trained in projection methods

# Our Objective

1. To make mortality projections for the next 30 years that account for future advancements in medicine and public health.
2. To examine mortality for specific causes of death
3. To understand which specific factors will be responsible for the increases

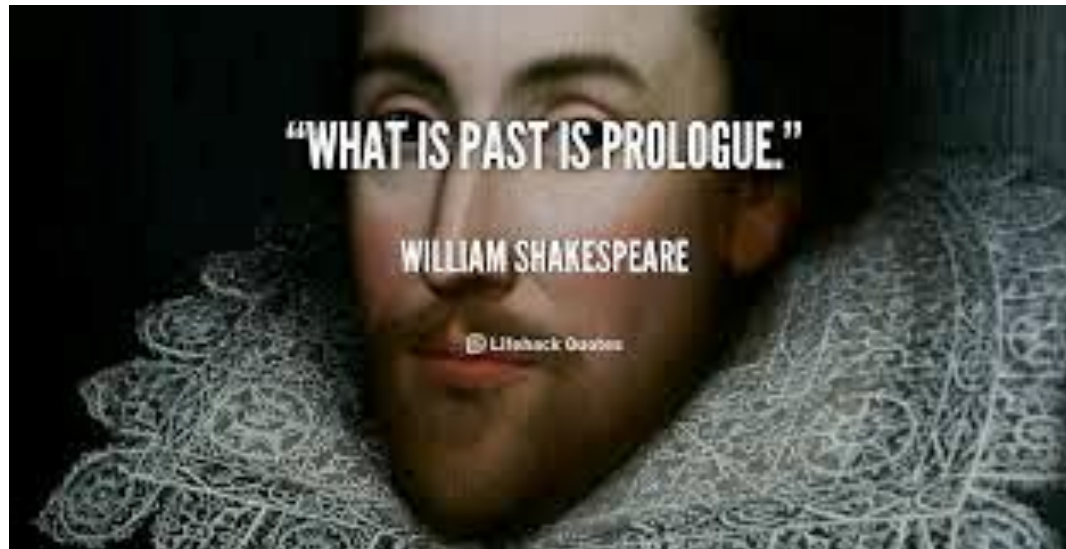
# Data & Methods

- Cause of death information 2009: The Wonder database (CDC), counts of deaths by cause, age, and sex
- Overall mortality 1933-2009: The Human Mortality Database (UC Berkeley)
- Focus group with clinical experts & their mortality forecasts by cause, age, and sex
- Discussions about the public health and clinical changes responsible for improvements



# Is The Past Prologue?

- **Will the illnesses that have increased life expectancy in the past have the same impact in the future?**



# Causes of Death in the US in 2009

**Table 1. Distribution of deaths (%) by broad causes of death for the US Population in 2009.**

<b>Causes</b>	<b>Females</b>	<b>Males</b>
Cardiovascular D.	32.8	31.6
Neoplasm	22.8	25.0
Respiratory D.	10.2	9.4
Nervous Sys.	6.6	4.4
External	4.7	10.0
Diabetes M.	4.1	4.0
Other	18.9	15.6

Source: CDC, WONDER datafile.

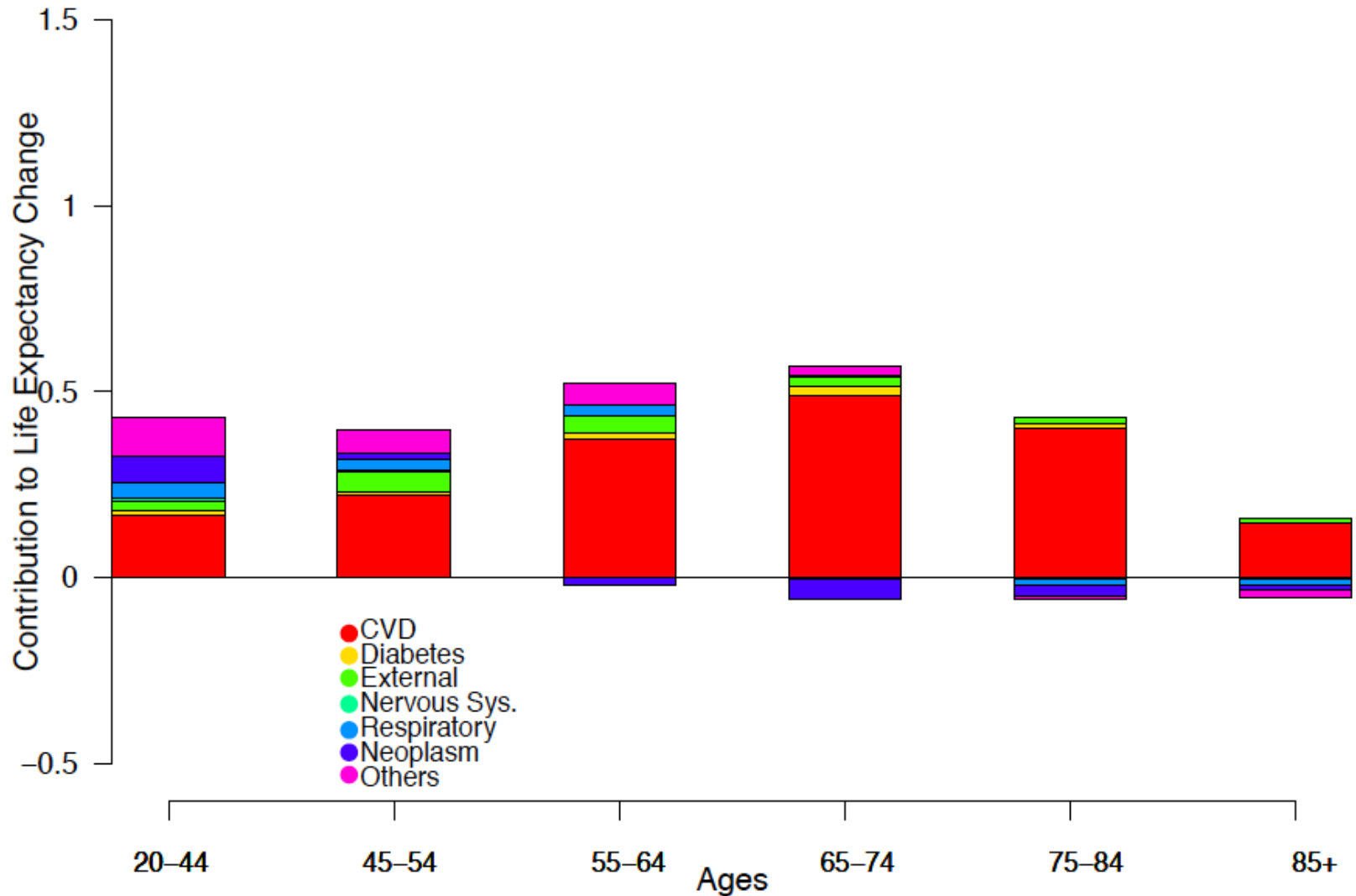
Note: External includes accidents, homicide and suicides.

# What illnesses were responsible for the increases in life expectancy during the 1970 -2007 period?

- We examined the 6 main ones
  - CVD – Cardiovascular disease
  - Cancer – Neoplasm
  - External factors – injuries, homicides, suicides
  - Nervous system- stroke, Alzheimer's, MS
  - Diabetes and other endocrine diseases
  - Respiratory –COPD, asthma, pneumonia
  - Other

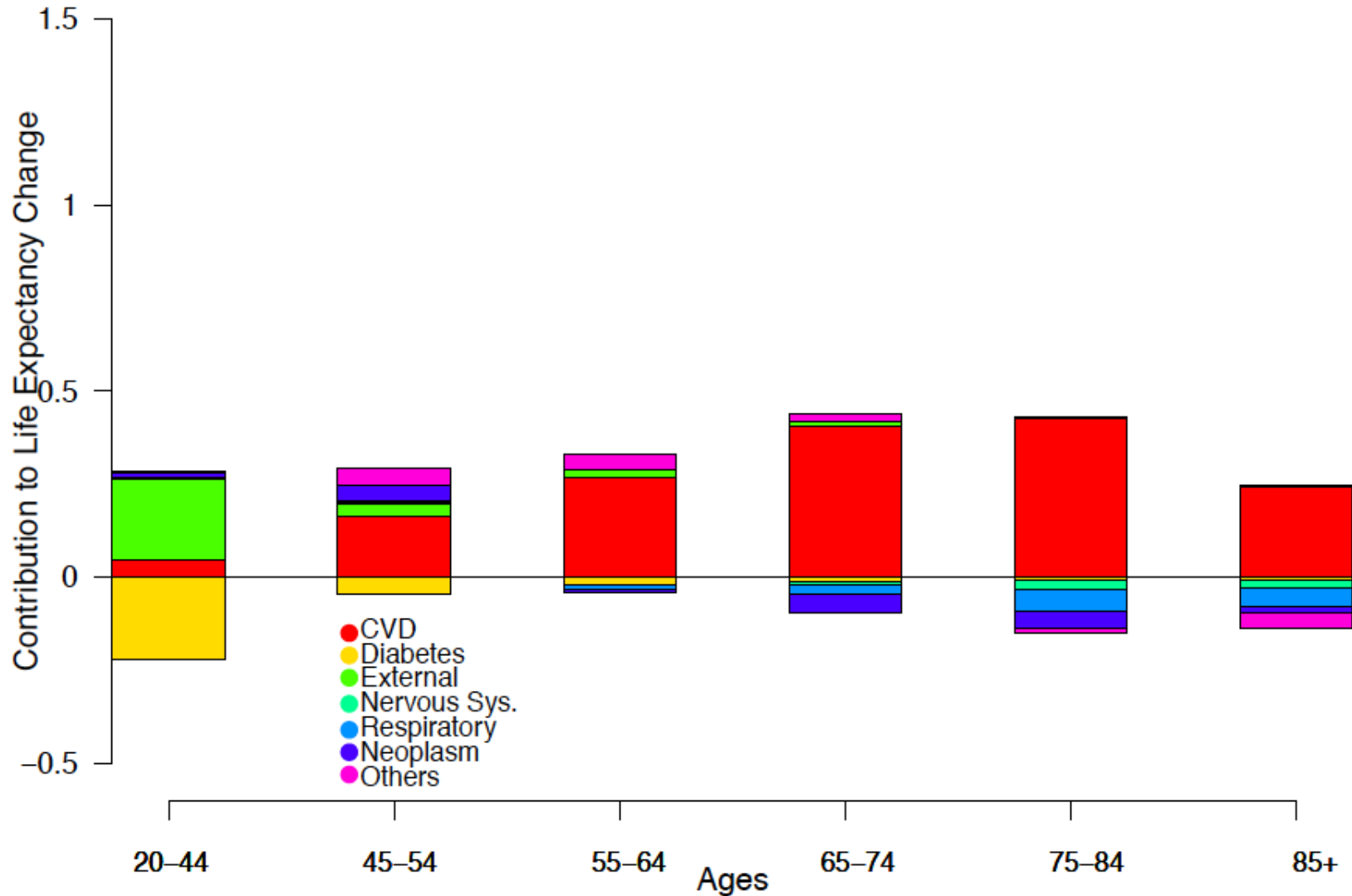
# Age-and cause-contribution to the 2.32 years of difference in LE from 1970 to 1980

## Mostly CVD



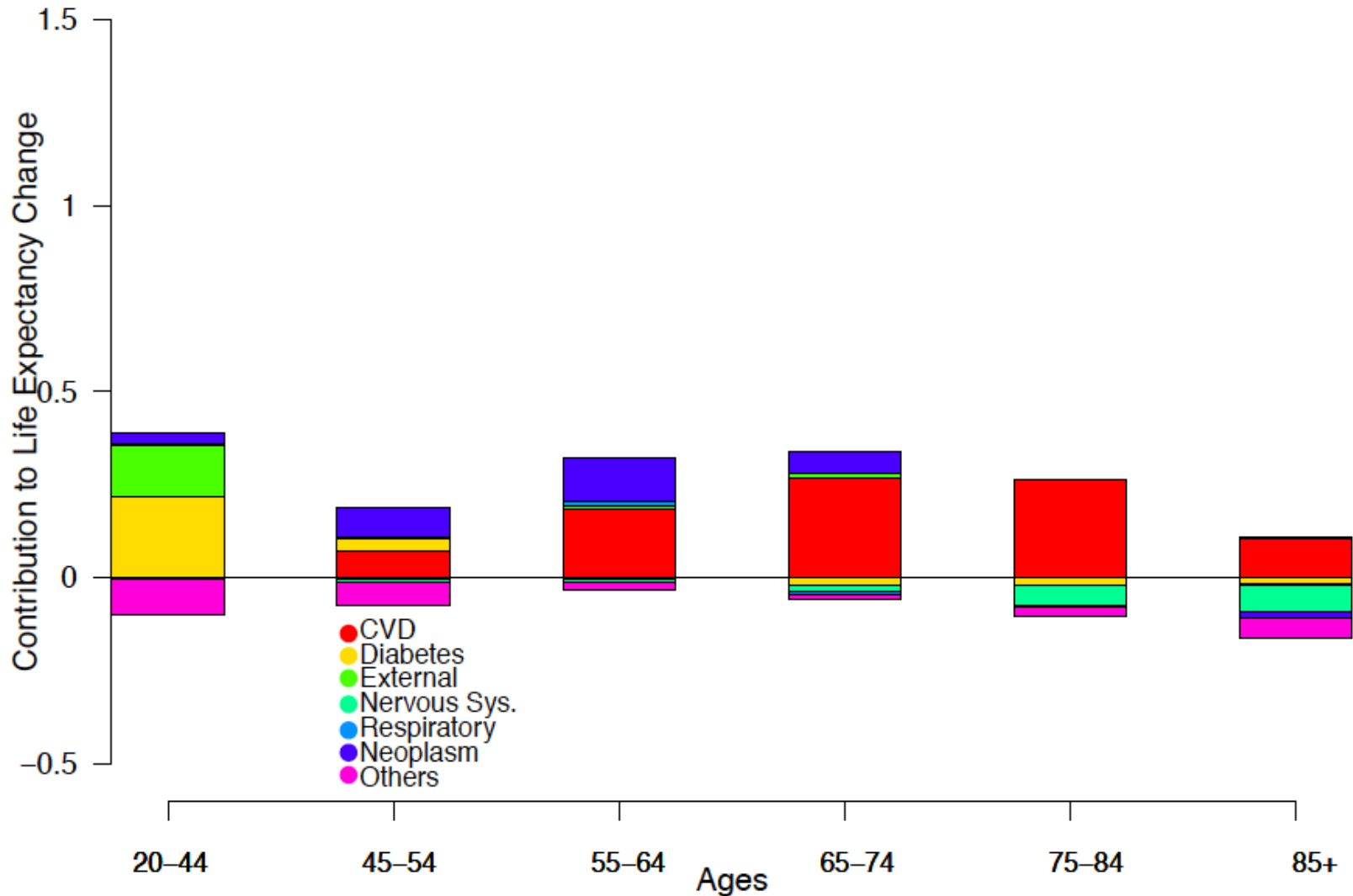
# Age-and cause-contribution to the 1.34 years of difference in LE from 1980 to 1990

## Mostly CVD



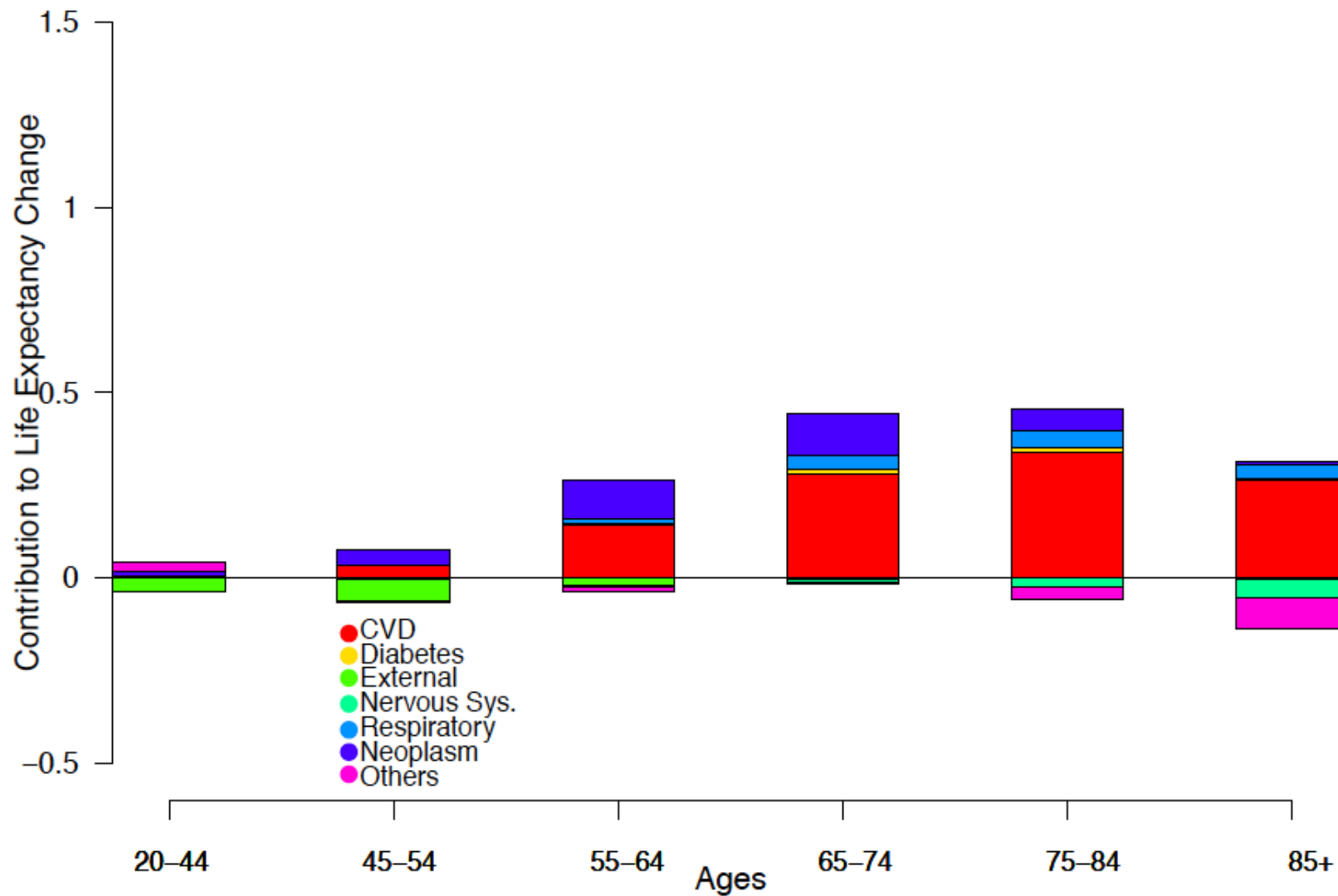
# Age- and cause-contribution to the 1.07 years of difference in LE from 1990 to 2000

## Mostly CVD



# Age- and cause-contribution to the 1.24 years of difference in LE from 2000 to 2007

## Mostly CVD but occurring later



# Summary of Past Trends

- Almost all of the improvement in life expectancy in the 1970-2007 period is attributable to cardiovascular disease
- The increases in life expectancy are occurring later in life



# Will These Trends Continue?

- We created expert panels
- Identified clinical and content experts in disease and sub-clinical areas from the Johns Hopkins School of Medicine and School of Public Health
- We interviewed 36 experts (42% full professors, 42% associate professors, 17% assistant professors)

# Overall mortality: JHU expert opinion

- 7 panels of between 3 and 6 experts
  - 6 medical and one public health
- Each expert made their own estimates
- Overall mortality,  $m(x)$ , is the combination of deaths from cardiovascular disease, cancer, external causes, diabetes, respiratory diseases, nervous system and *other causes* of death.

# Clinical Expert Panels

Consulted independently for 2 hours each expert group using a common protocol:

- a) 15 min, presentation of the trends in overall & cause specific mortality in the last 30 yrs
- b) 15 min, given 2009 age- & cause-specific death rates for 6 age groups and individually asked to estimate the % decline by 2040
- c) 1.5 hour the experts debated on the reasons for the expected declines.

Each expert forecasted: age, sex, cause-specific death rates  $m(x,s,i)$  in their clinical specialty

Ages	Mx-Fem	Mx-Male
0-44	0.02	0.010
45-54	0.08	0.040
55-64	.	.
65-74	.	.
75-84	.	.
85+	.	.

# Overall Mortality

- Overall mortality,  $m(x)$ , is the combination of deaths from cardiovascular disease, cancer, external causes, diabetes, respiratory diseases, nervous system and other causes of death.
- We assumed death rates from *other causes* changed at the same rate as the mean of all 6-panels.

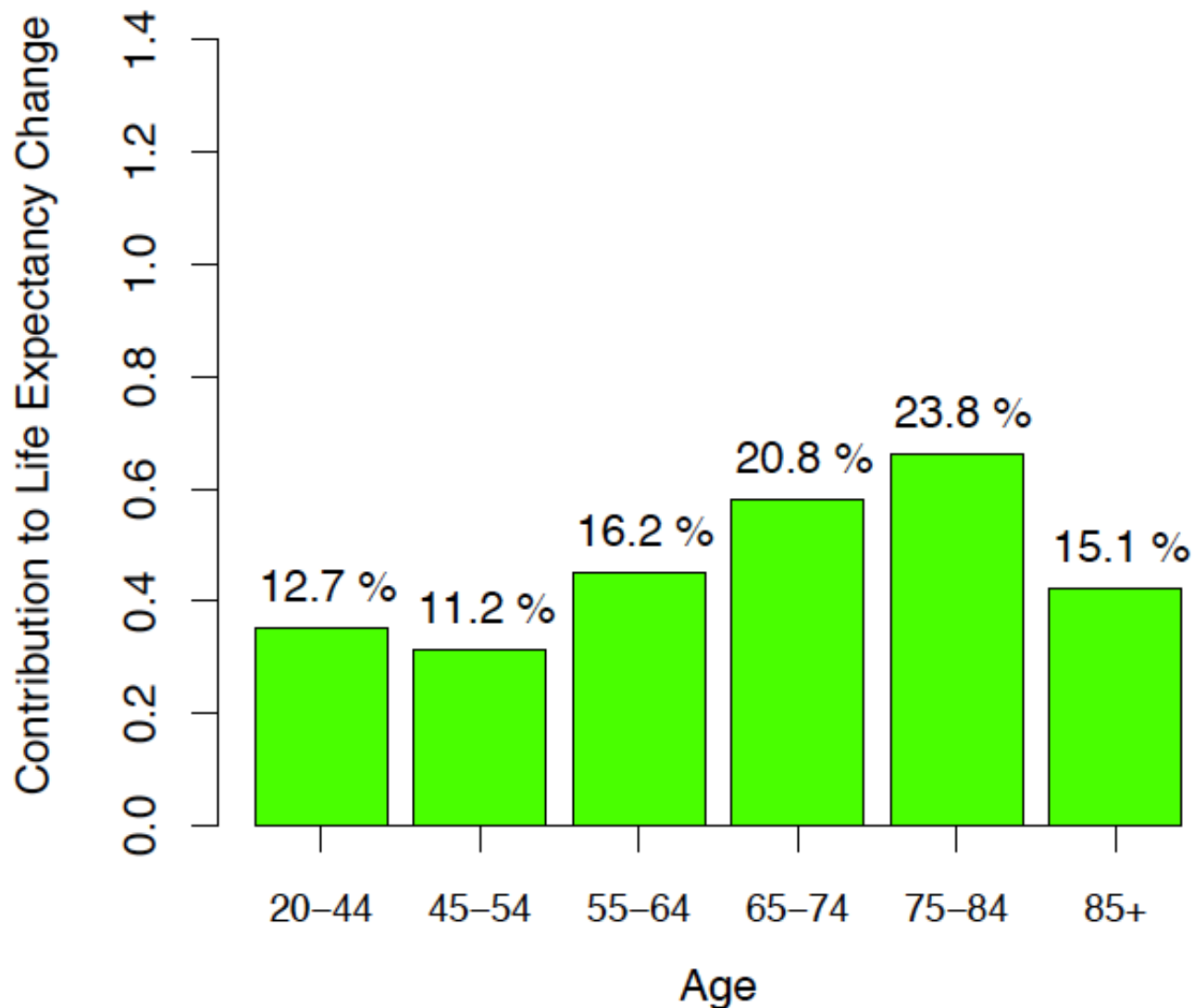
# Summing of Individual Expert Opinions

- First we summarized the projections by disease and then across the diseases
- $m(x) = m(x, \text{CVD}) + m(x, \text{cancer}) +$   
 $m(x, \text{external}) + m(x, \text{diabetes}) +$   
 $m(x, \text{respiratory}) + m(x, \text{nervous}) + m(x, \text{other})$

# Life expectancy at age 20 by sex for the US population, 2009 & JHU experts in 2040.

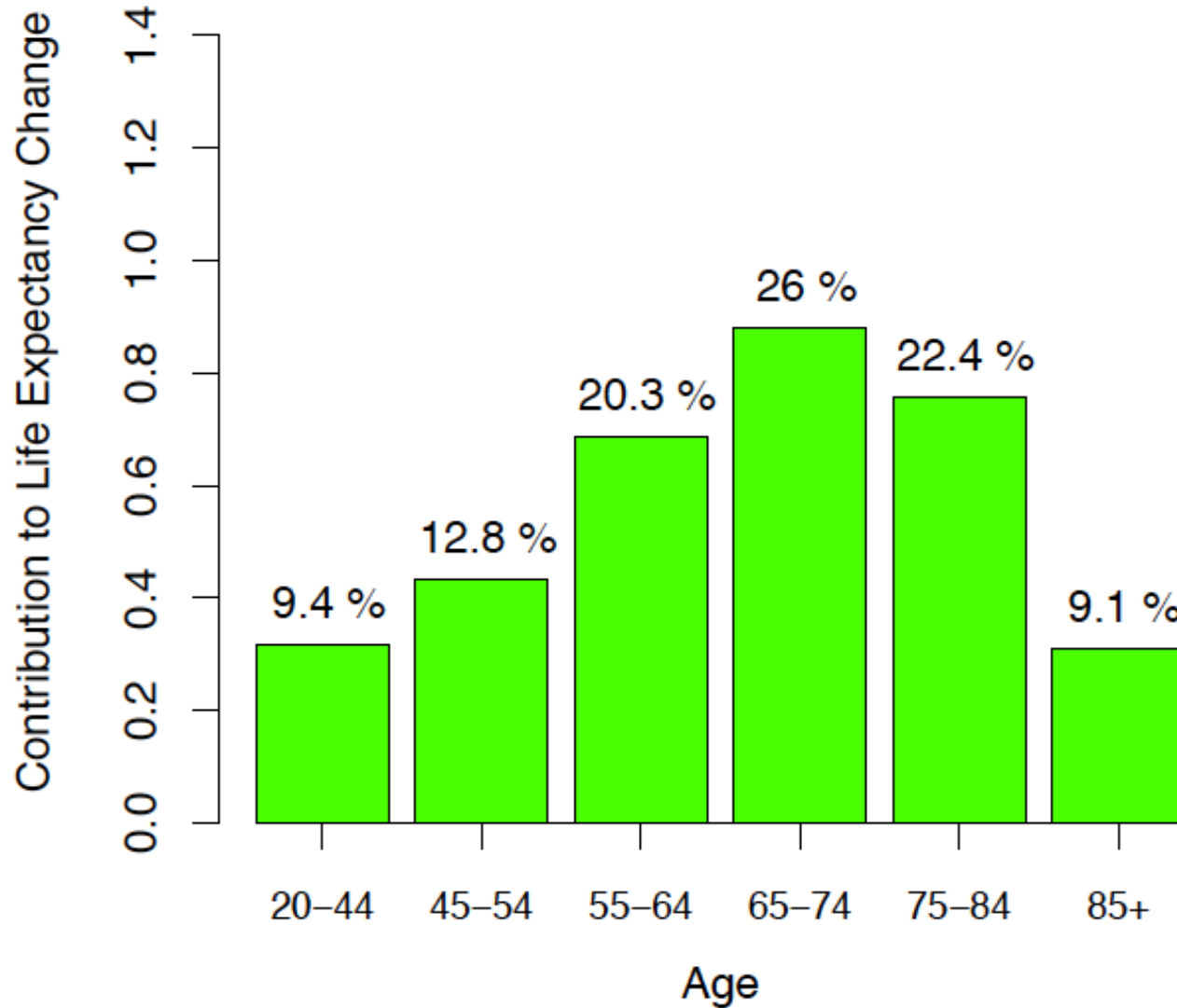
<u>Year</u>	<u>Gender</u>	
	Female	Male
2040	<b>64.6</b>	<b>60.5</b>
2009	<b>61.8</b>	<b>57.1</b>
Change	<b>2.8</b>	<b>3.4</b>

# Age-contribution to the 2.8 years of difference in females at age 20





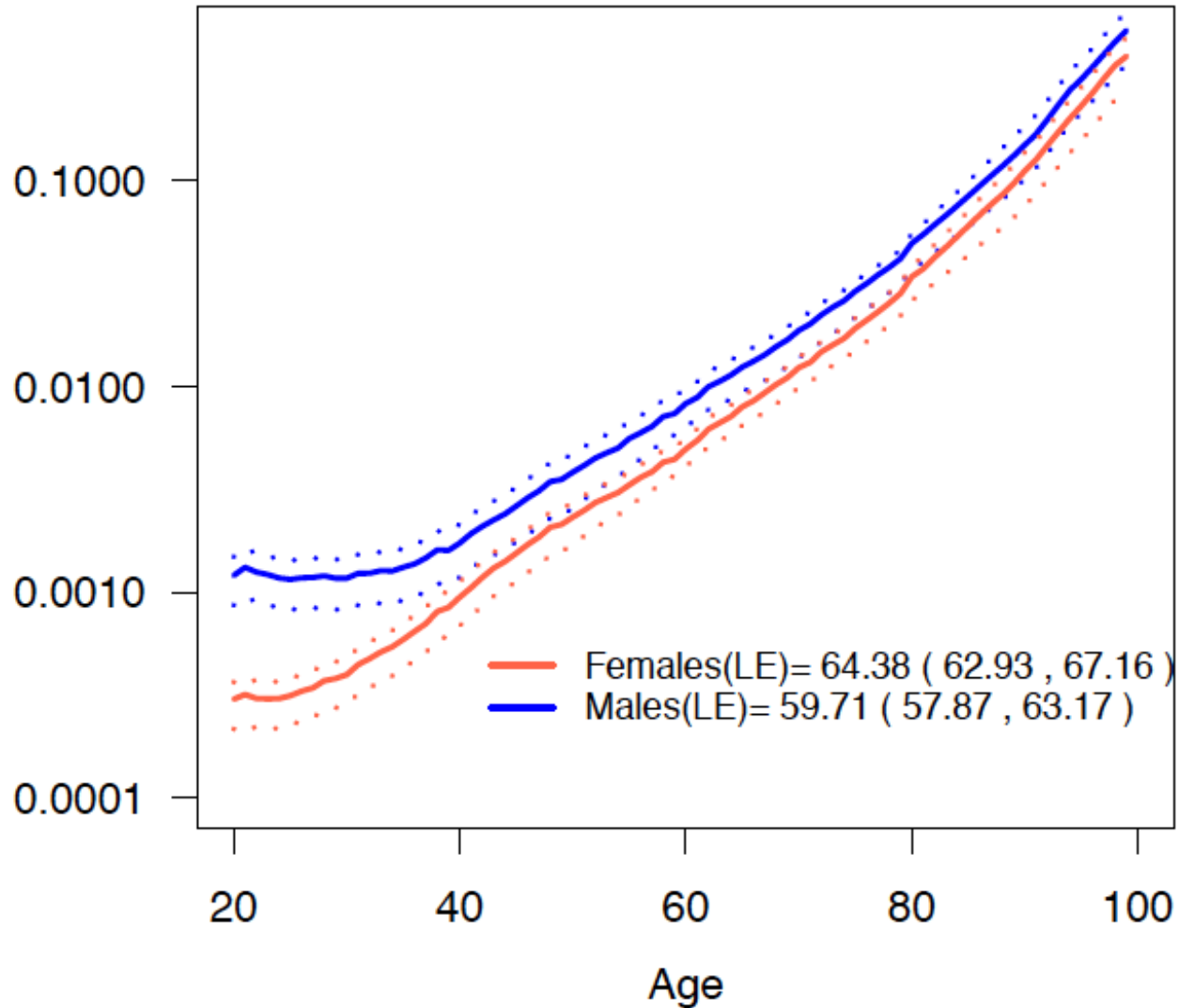
# Age-contribution to the 3.4 years of difference in males at age 20



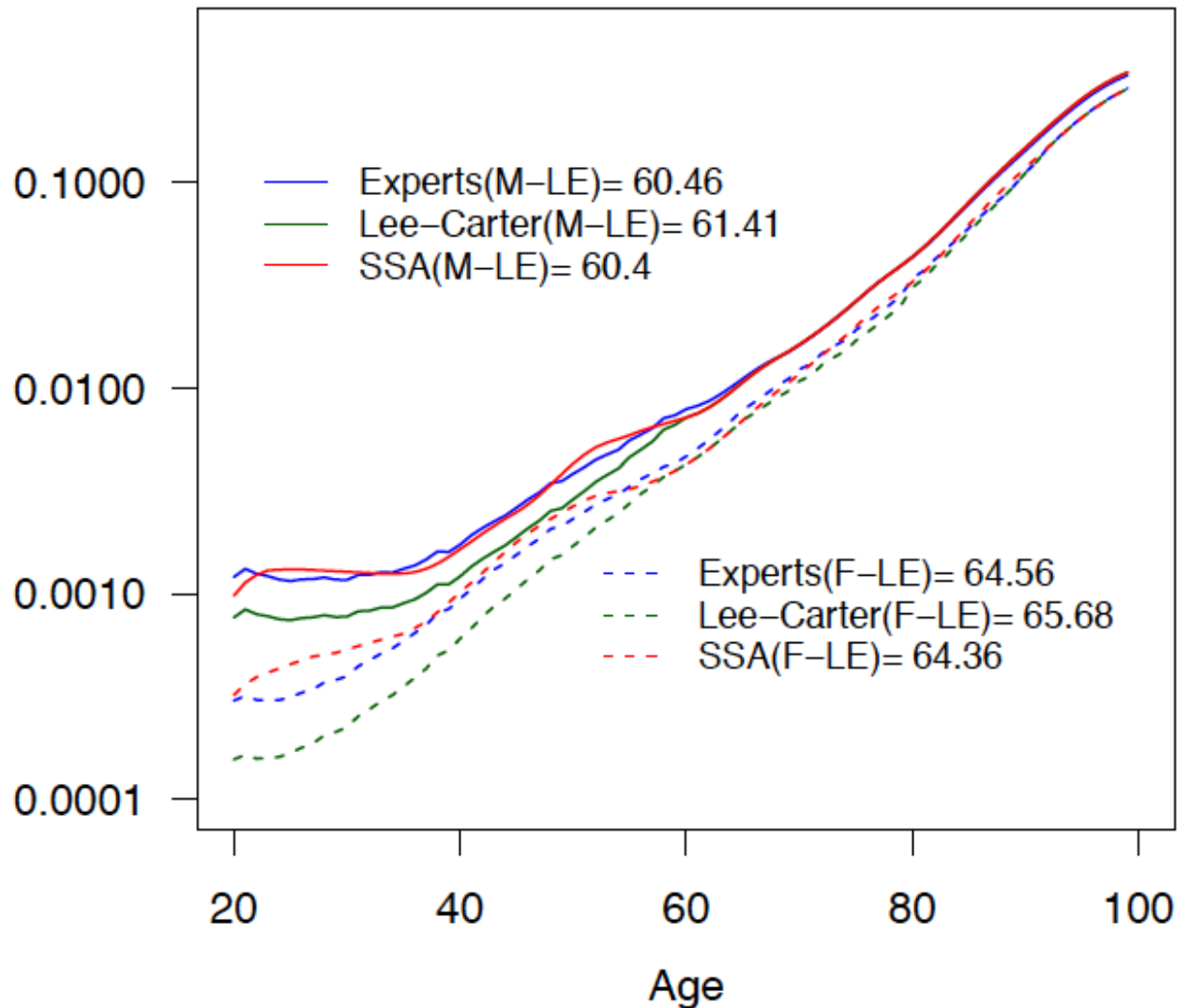
# Combining All The Results

- We took each JHU expert's recommendations and estimated a variety of possible combinations of values. Here we present the *average of each panel*, as well as the 95% CI.

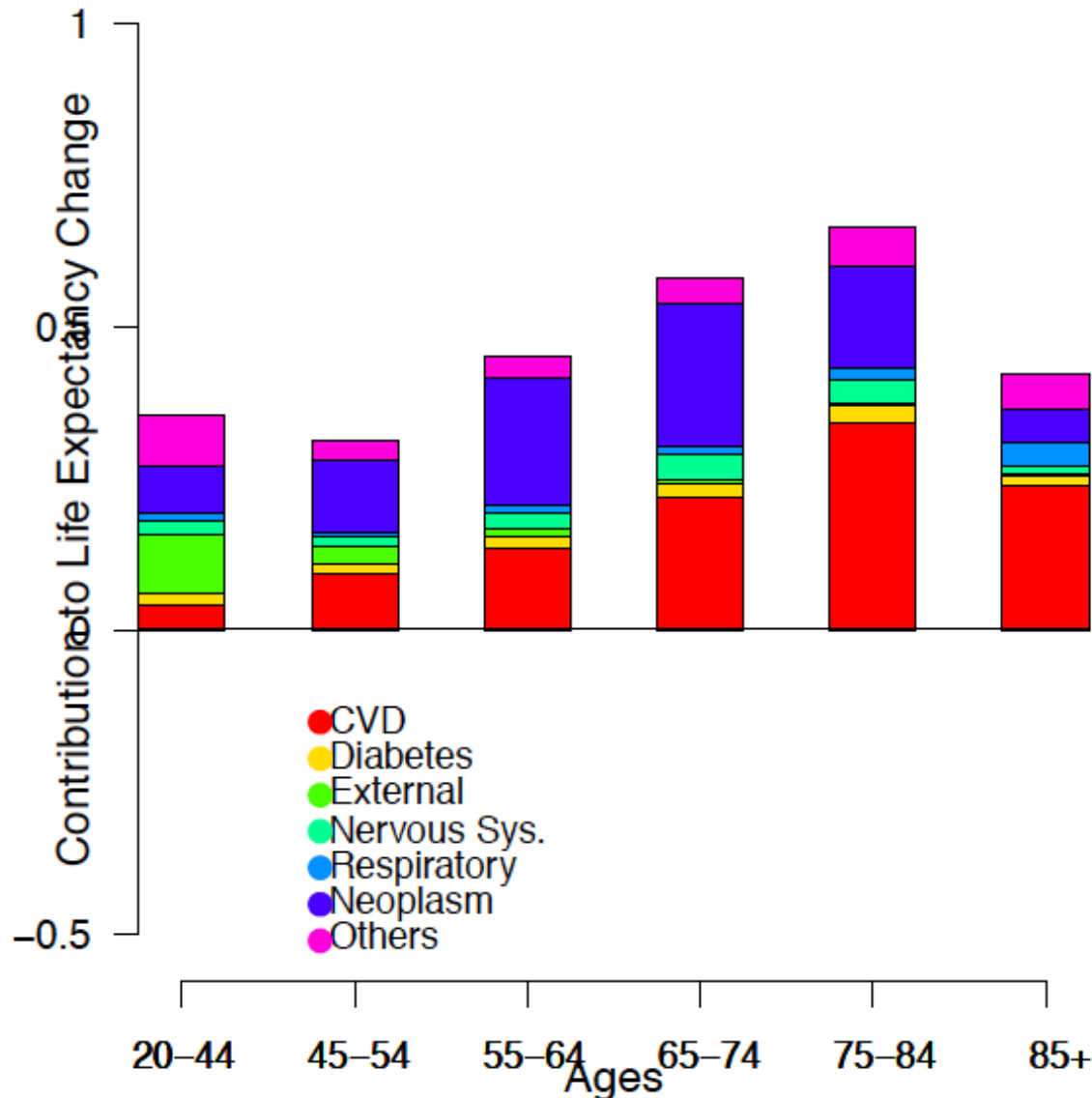
# Age-Specific Death Rates for US Females and Males in 2040



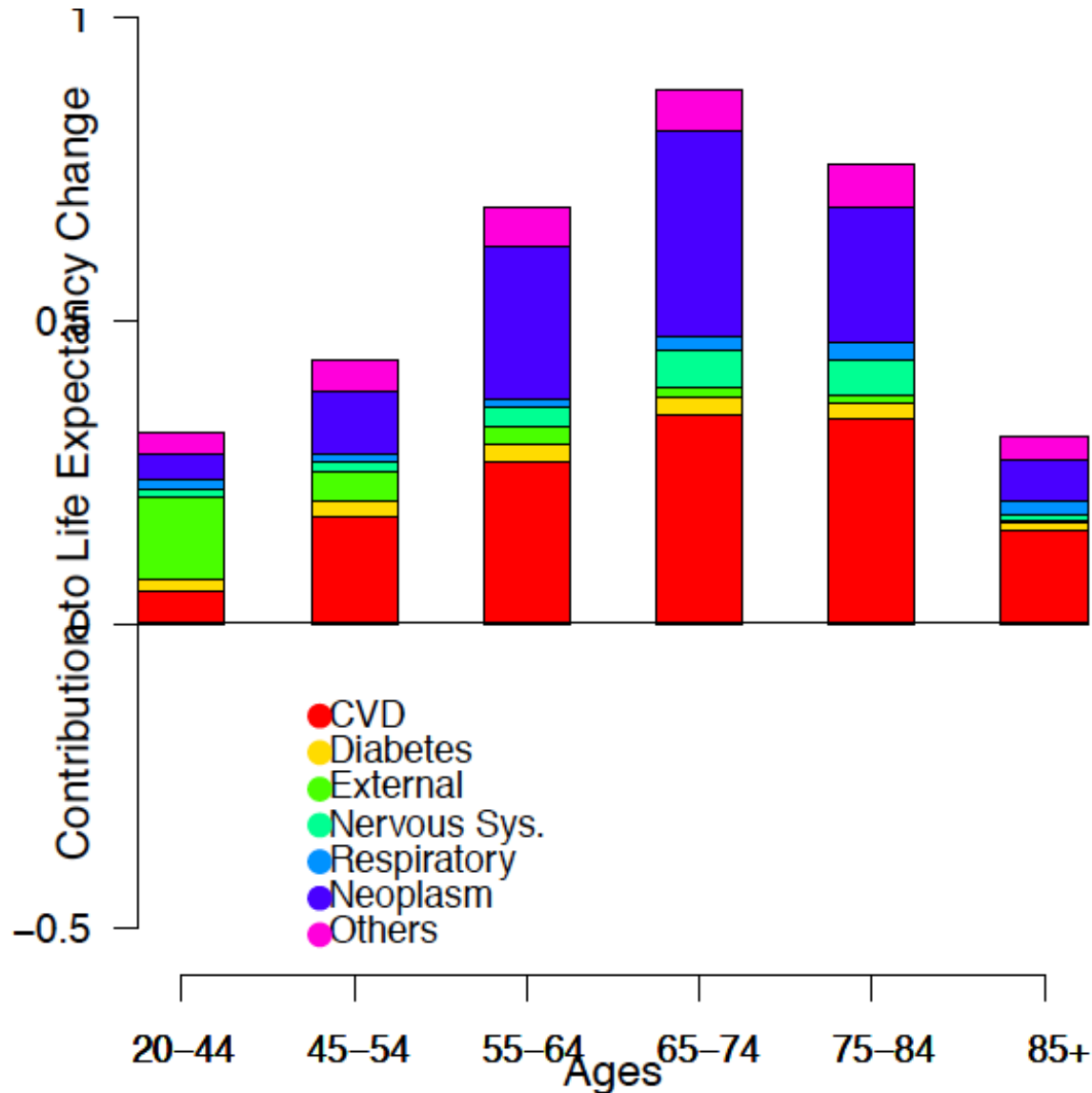
# Comparison of age-specific death rates from JHU Experts, SSA, and Lee-Carter at Age 20



# Age and Cause Contribution to the 2.79 Difference in Female LE from 2009 to 2040



# Age and Cause Contribution to the 3.38 Difference In Male LE from 2009 to 2040



# Age- & cause-contribution to the change in life expectancy

Most of the increase in life expectancy by period - attributable to causes of death

<b>Period</b>	<b>Main cause of death</b>
1970-2009	Cardiovascular disease
2009-2040	Cardiovascular and cancers

# Summary

- As forecasted by JHU experts, female and male life expectancies in the US will keep increasing, by 2040 it will be approximately 3 years higher than today.
  - Men slightly faster than women
- CVD and cancers will be the driving causes of the changes in mortality.
- The experts' discussed some of the reasons of these changes in mortality.



# What The Experts Said About Future Trends

- “I think we will continue, but I think that the velocity will slow.” – CVD Doctor 2
  - “The advances are likely to come in drug delivery systems, for example. You know, the technology works a hell of a lot better than modifying human behavior.” – CVD Doctor 1
- “But you know, I can't stop you from smoking. I can't stop you from breathing the air.” - Respiratory Disease Doctor 4
  - “[T]argeted therapy have very limited efficacy in smoking related lung cancer. What's made a difference in the 15% of lung cancer that is in never smokers. ...you can actually pre-biopsy your patient, tailor your therapy to what that biopsy tells you, you can actually match your drugs to it.” – Cancer Doctor 3
- “I think it's going to largely depend on physician's willingness to code diabetes as the underlying cause of death on the death certificate.” - Diabetes Doctor 3

# What Will Improve Mortality

	Primary Prevention	Secondary Prevention	Tertiary Prevention
Cardiovascular Disease	<ul style="list-style-type: none"><li>• Smoking reductions</li><li>• Improved diet</li><li>• Greater use of statins and aspirin</li><li>• Improvements in genomics leading to better risk prediction</li></ul>	<ul style="list-style-type: none"><li>• Technologies simplifying medication adherence</li></ul>	<ul style="list-style-type: none"><li>• Stem cell therapies</li><li>• Artificial hearts</li><li>• Greater use of percutaneous therapies</li><li>• Greater use of ICDs</li></ul>
Cancer	<ul style="list-style-type: none"><li>• Smoking reductions</li><li>• New vaccines that prevent cancers</li></ul>	<ul style="list-style-type: none"><li>• Earlier diagnosis and treatment</li><li>• Epi-genetic testing</li></ul>	<ul style="list-style-type: none"><li>• New Immunotherapies</li></ul>

# What Will Improve Mortality

	Primary Prevention	Secondary Prevention	Tertiary Prevention
Respiratory Disease	<ul style="list-style-type: none"><li>• Smoking reductions</li><li>• Declines in air pollution</li></ul>	<ul style="list-style-type: none"><li>• Increased use of spirometry</li><li>• Better classifications of IPF and COPD subtypes</li></ul>	<ul style="list-style-type: none"><li>• Longer acting treatments</li></ul>
Alzheimer's Disease	<ul style="list-style-type: none"><li>• Smoking reductions</li><li>• Physical activity</li><li>• Improving sleeping habits</li></ul>	<ul style="list-style-type: none"><li>• Cerebrospinal Fluid Profile</li></ul>	

# What Will Improve Mortality

	Primary Prevention	Secondary Prevention	Tertiary Prevention
External Causes	<ul style="list-style-type: none"><li>• Smoking reductions</li><li>• Binge alcohol drinking reductions</li></ul>		<ul style="list-style-type: none"><li>• Improvements in trauma care</li></ul>
Diabetes Mellitus	<ul style="list-style-type: none"><li>• Smoking reductions</li><li>• Improved diet</li><li>• Immunotherapy curing Type-1 diabetes</li></ul>	<ul style="list-style-type: none"><li>• Increasing use of insulin</li><li>• Development of faster acting insulins</li></ul>	<ul style="list-style-type: none"><li>• Health care reform – intensive life style interventions</li></ul>