Measuring population health
Concepts and applications

Session overview

- Background
- Review of types of summary measures
  - Health expectancy measures
  - Health gap measures
- Causal attribution with summary measures
- Some empirical results

Comparative measurement of population health

Two key questions:

- How healthy is the population (on average)?
- What are the major health problems in the population?

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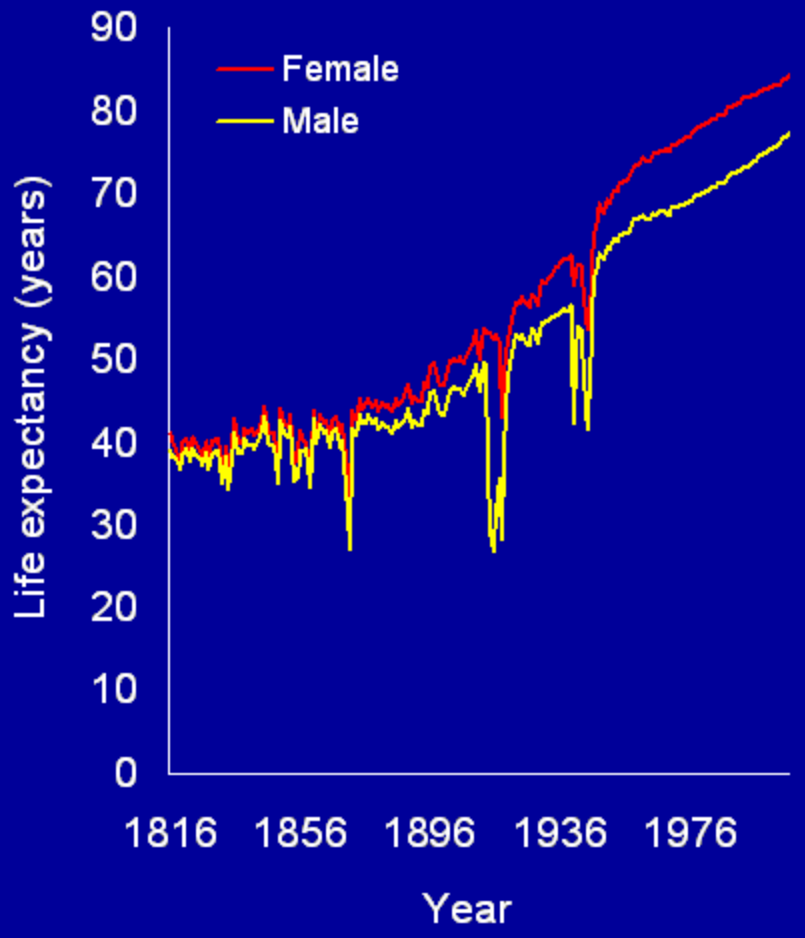
Life expectancy (y), France, 1816-2006



SOURCE: Human Mortality Database

Japan now home to world's oldest person

AP Associated Press

Yone Minagawa, 114, is congratulated by the staff at the Keiju nursing home at Fukuchi town in Fukuoka Prefecture (state), southwestern Japan Tuesday, Jan. 30, 2007. Minagawa was identified as the world's oldest person by the Guinness Book of World Records following the death Sunday of Emma Faust Tillman, also 114. The sign Minagawa is holding reads " Congratulations on being the world's oldest." (AP Photo/Kyodo News)

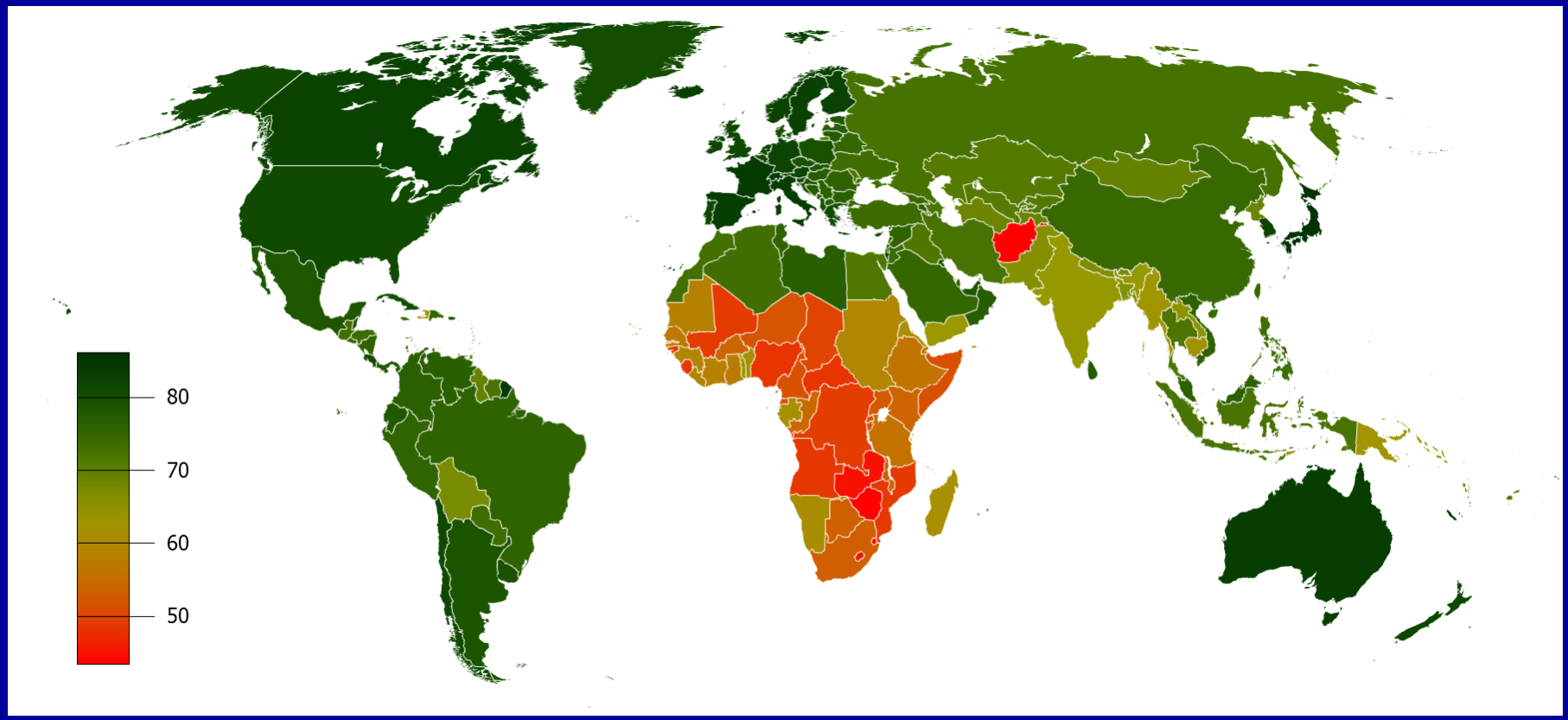
TOKYO --Two weeks after she turned 114, Yone Minagawa celebrated her long life again Tuesday when she learned she is believed to be the world's oldest person. Staff at the nursing home where Minagawa lives in southern Japan greeted her Tuesday with a poster that said, “Congratulations, you're No. 1.”

…The nursing home says she has a healthy appetite, and ventures to the dining room by a motorized wheelchair for meals when she feels up to it. She has a little trouble hearing, but can communicate fine …She chats with friends, combs her hair every morning, and seldom misses the weekly singalong. "She has a sweet tooth, so we have to watch her, otherwise she reaches out for seconds and thirds."

Minagawa inherited the title from Emma Faust Tillman, who died Sunday in Connecticut at age 115. Although Ms. Tillman tired easily in recent years and started sleeping most of the day soon after reaching 114, family members said her mind remained sharp and she occasionally still indulged in corn on the cob.

…Though it is perhaps impolite to mention, recent history suggests that Ms. Minagawa may not hold the crown for long. In the last month alone, the title of oldest person has changed hands three times. “The Guinness Book of World Records will not be able to keep up,” said Dr. L. Stephen Coles of UCLA. “This has been a pretty volatile time. Usually we’ve had a more stable No. 1 position.”

World life expectancy, 2008



Source: Human Development Report 2009

As mortality declines, do people enjoy greater longevity in good health or extended periods in declining health?

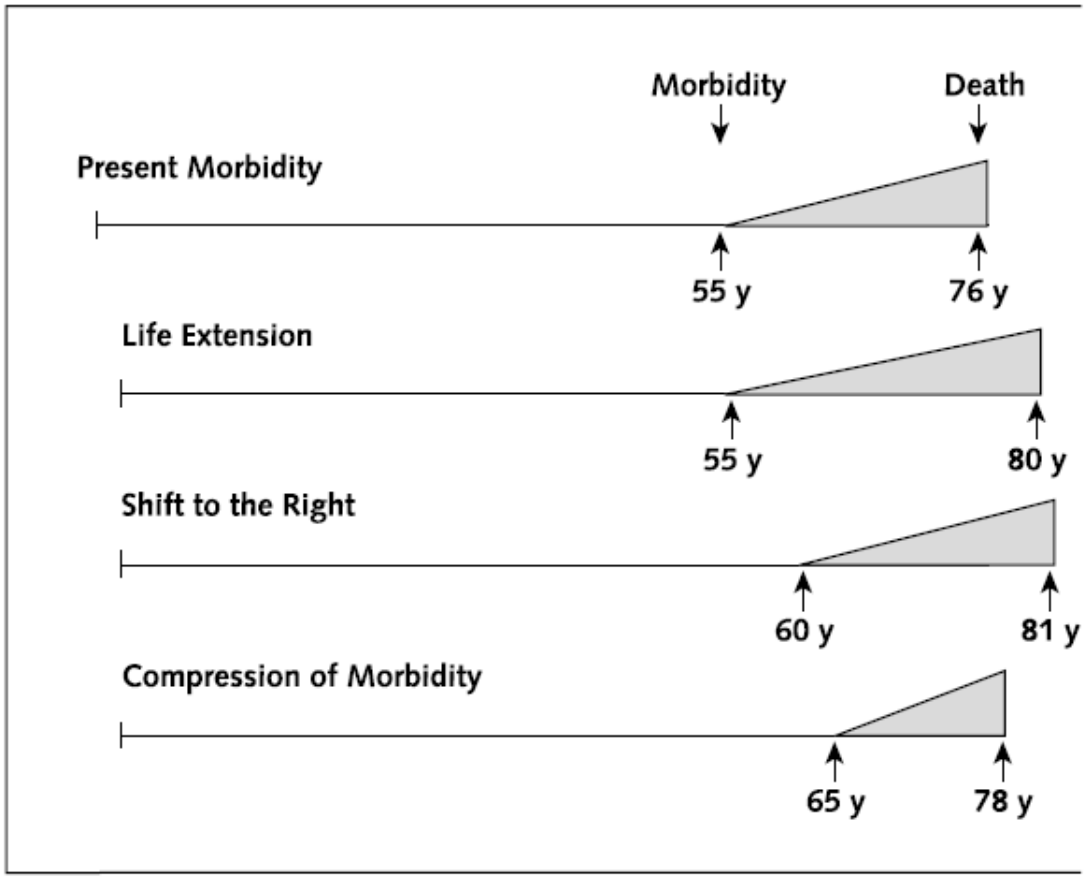
Competing hypotheses on aging

- **“Compression of morbidity” (Fries 1980)**

  Increase in life expectancy combined with postponement of serious disease and disability
- **“Expansion of morbidity” or “the failure of success” (Gruenberg 1977)**

  Prolonged life brings extra years in poorer health

Scenarios for morbidity and longevity



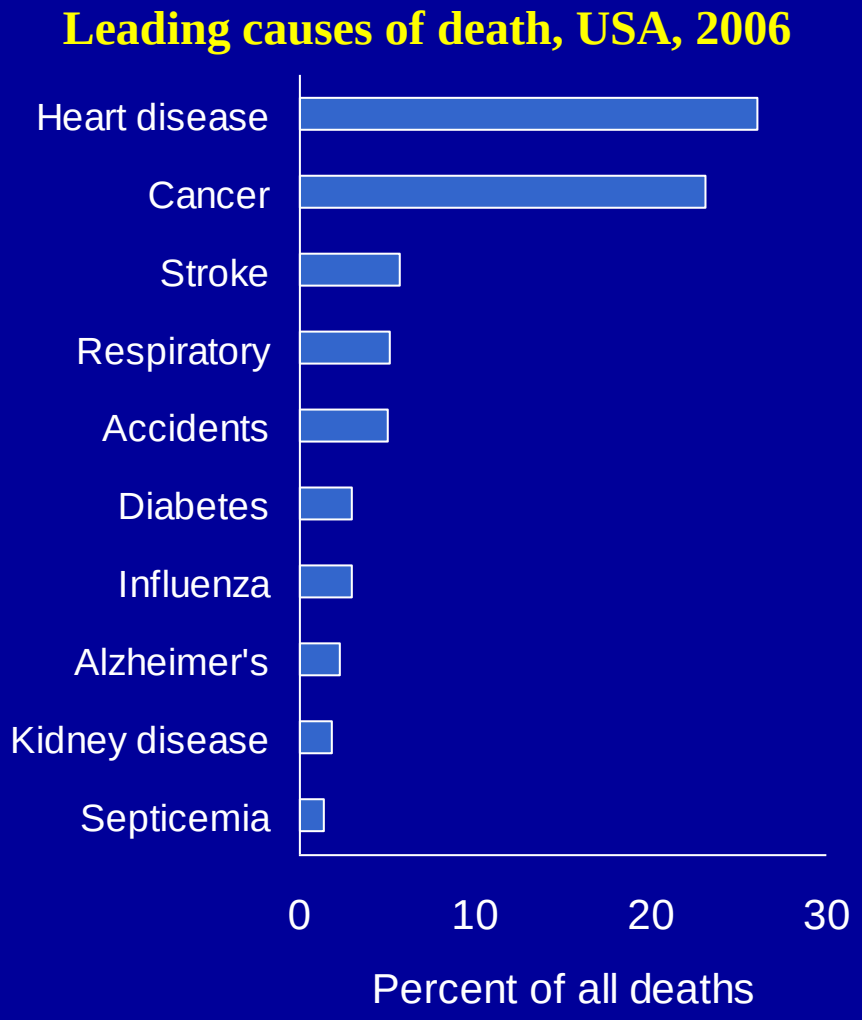
Present lifetime morbidity, portrayed as the shaded area, is contrasted with three possible future scenarios.

Source: Fries 2003

Comparative measurement of population health

Two key questions:

- How healthy is the population (on average)?
- **What are the major health problems in the population?**



SOURCE: NCHS 2009

If two diseases cause the same number of deaths, but one causes deaths at old ages and the other at young ages, do the two diseases represent the same "size" problem?

How do we measure the burden of problems like depression and osteoarthritis?

- Indicators of population health needed for comparison, monitoring, evaluation
- As life expectancy has risen, mortality rates alone insufficient
- Summary measures of population health combine information on mortality and non-fatal health outcomes

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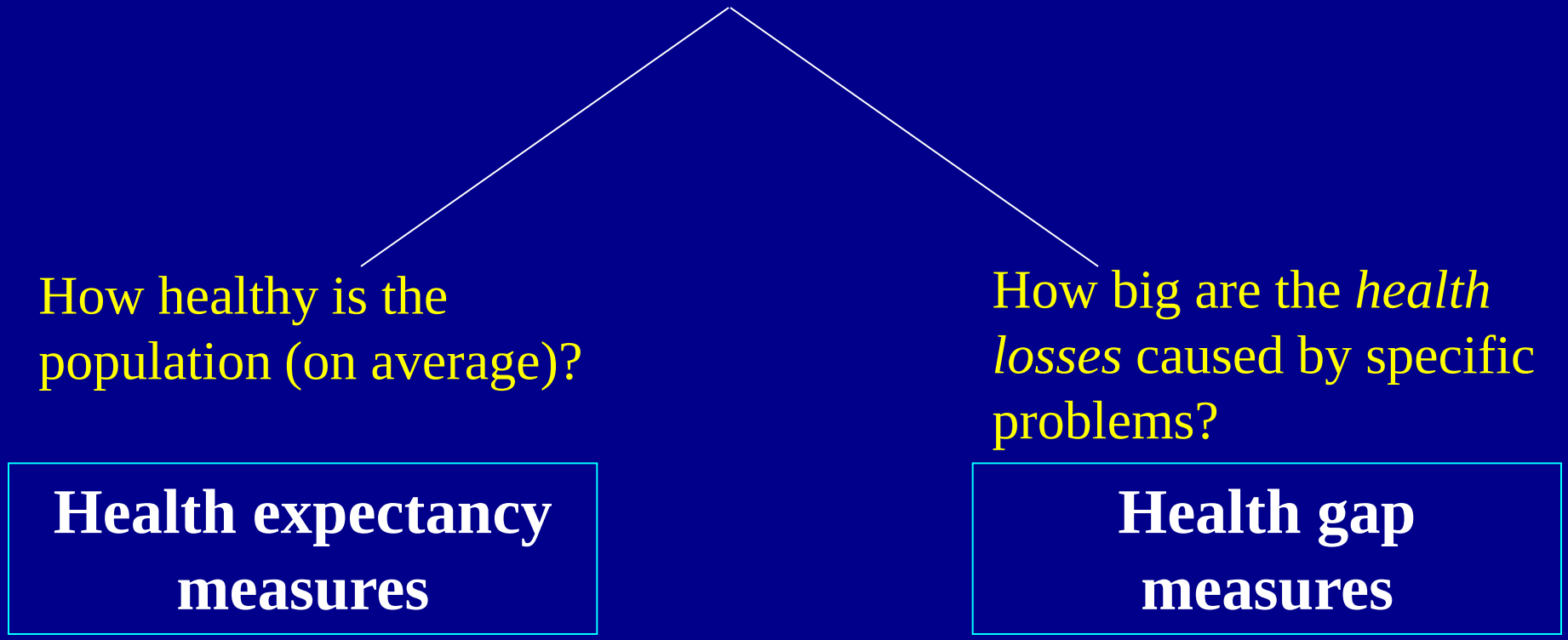
Two broad families of summary measures of population health correspond to two major types of questions



An analogy to measures of the economy

- How do we measure the overall health of the economy?

- How do we measure the magnitude of material losses associated with major catastrophic events (e.g. global financial crisis, terror attacks, natural disasters)?

An analogy to measures of the economy

- How do we measure the overall health of the economy?
  - Gross domestic product (GDP) is the most familiar summary measure of productive economic activity in a country in a given year
  - GDP per capita is often taken as an indicator of living standards
  - Common benchmarks defined in terms of GDP (e.g. recession = decline in GDP for 2 consecutive quarters)

An analogy to measures of the economy

- How do we measure the magnitude of material losses associated with major catastrophic events?
  - Quantify consequences of various types

    For example, Hurricane Katrina destroyed 30 oil platforms; caused closure of nine refineries; destroyed the Gulf Coast highway infrastructure; destroyed 1.3 million acres of forest lands; destroyed thousands of houses; displaced thousands of residents; left hundreds of thousands of residents unemployed; etc.
  - Translate consequences into monetary values

    The total economic cost of Katrina is estimated at more than $150 billion, making it the costliest natural disaster in U.S. history

SOURCE: Burton et al. 2005

An analogy to measures of the economy

- For summary economic measures, ***dollars*** (or valuations in other currencies) are used as the unit of account so that different types of goods, services and material consequences can be compared
- For summary health measures, the unit of account is ***time***

  … because we care about *extending the length* of living and *reducing the duration* of illness and suffering

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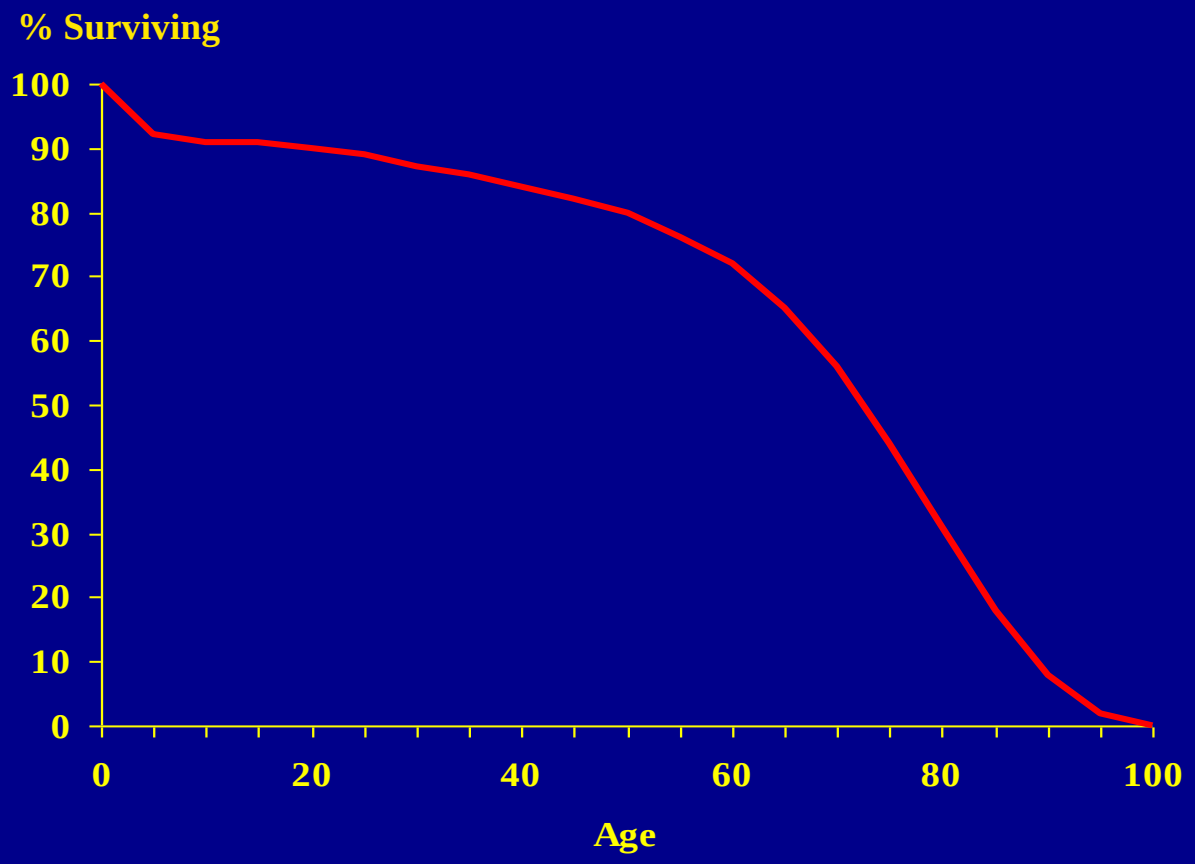
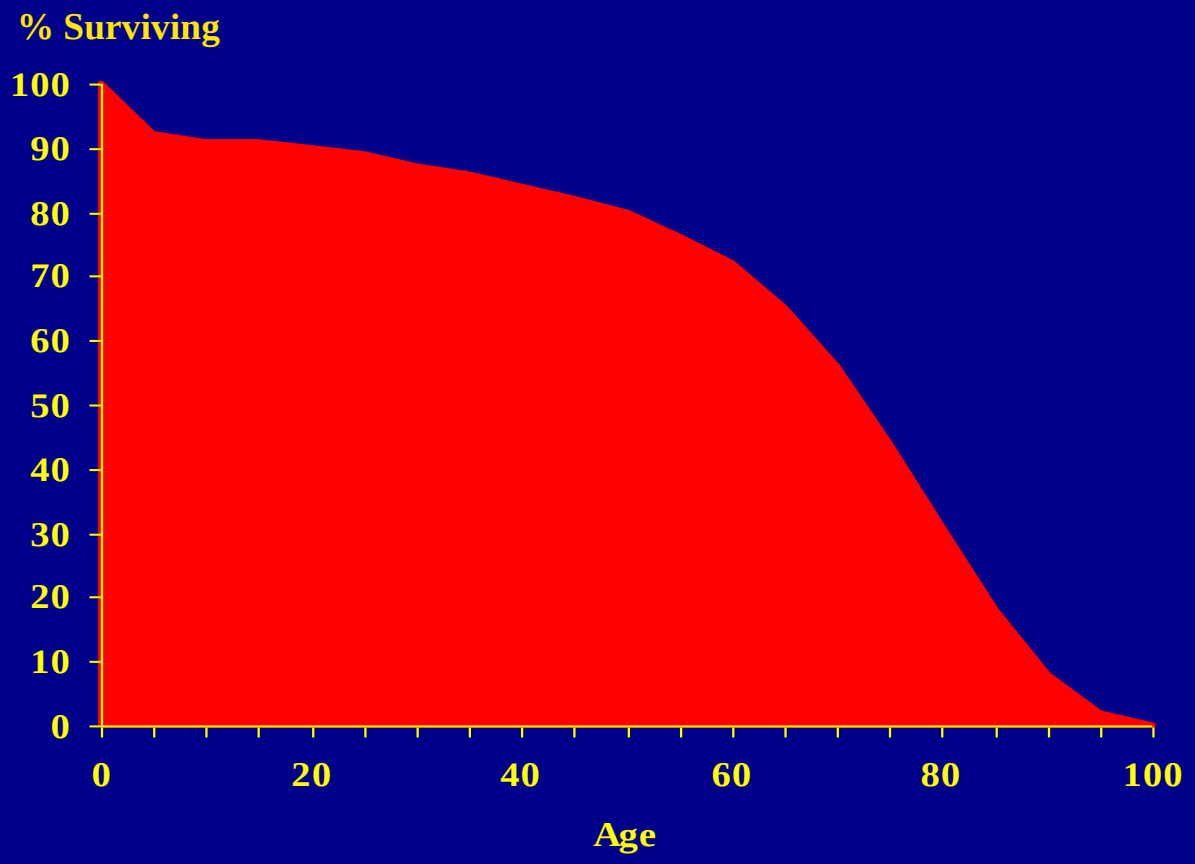
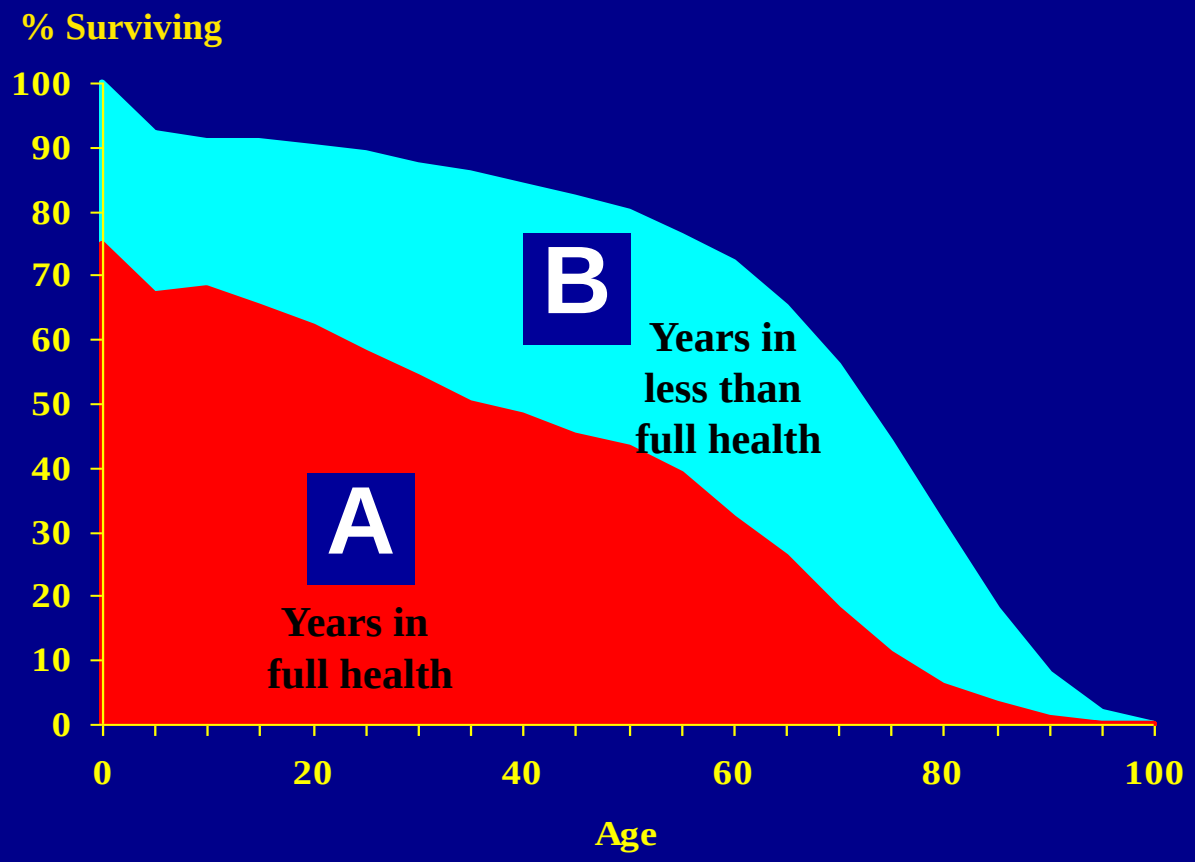
Health expectancy



Health expectancy



Health expectancy



Health Expectancy
= A + *vB**
where *v* is average value of states in B

Health expectancy measures

- Constructed on life expectancy
- Incorporate average health levels experienced by population alive at each age
- Equals equivalent number of years of life expectancy in full health

From dichotomous to polytomous measures

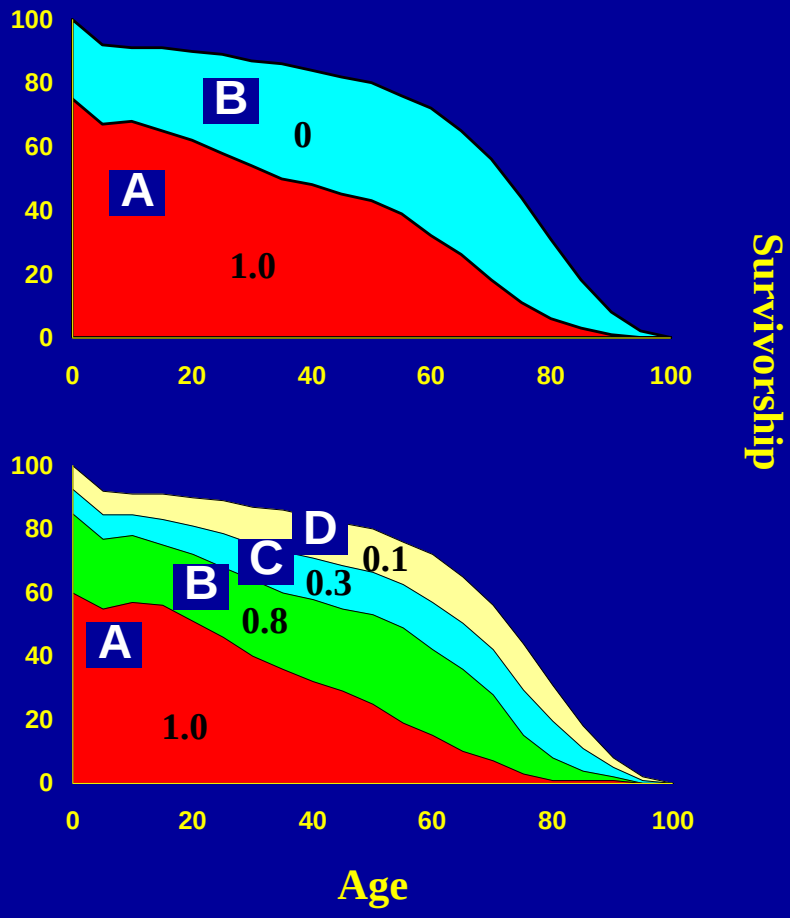
- Life expectancy is area under survivorship curve
- Health expectancy deducts for time in ill health, weighted for severity

Example 1: dichotomous weights

- LE = A + B
- HE = v_AA + v_BB
  = (1)(A) + (0)(B) = A

Example 2: polytomous weights

- LE = A + B + C + D
- HE = v_BA + v_BB + v_CC + v_DD
  = (1)(A) + (0.8)(B) + (0.3)(C)
  + (0.1)(D)



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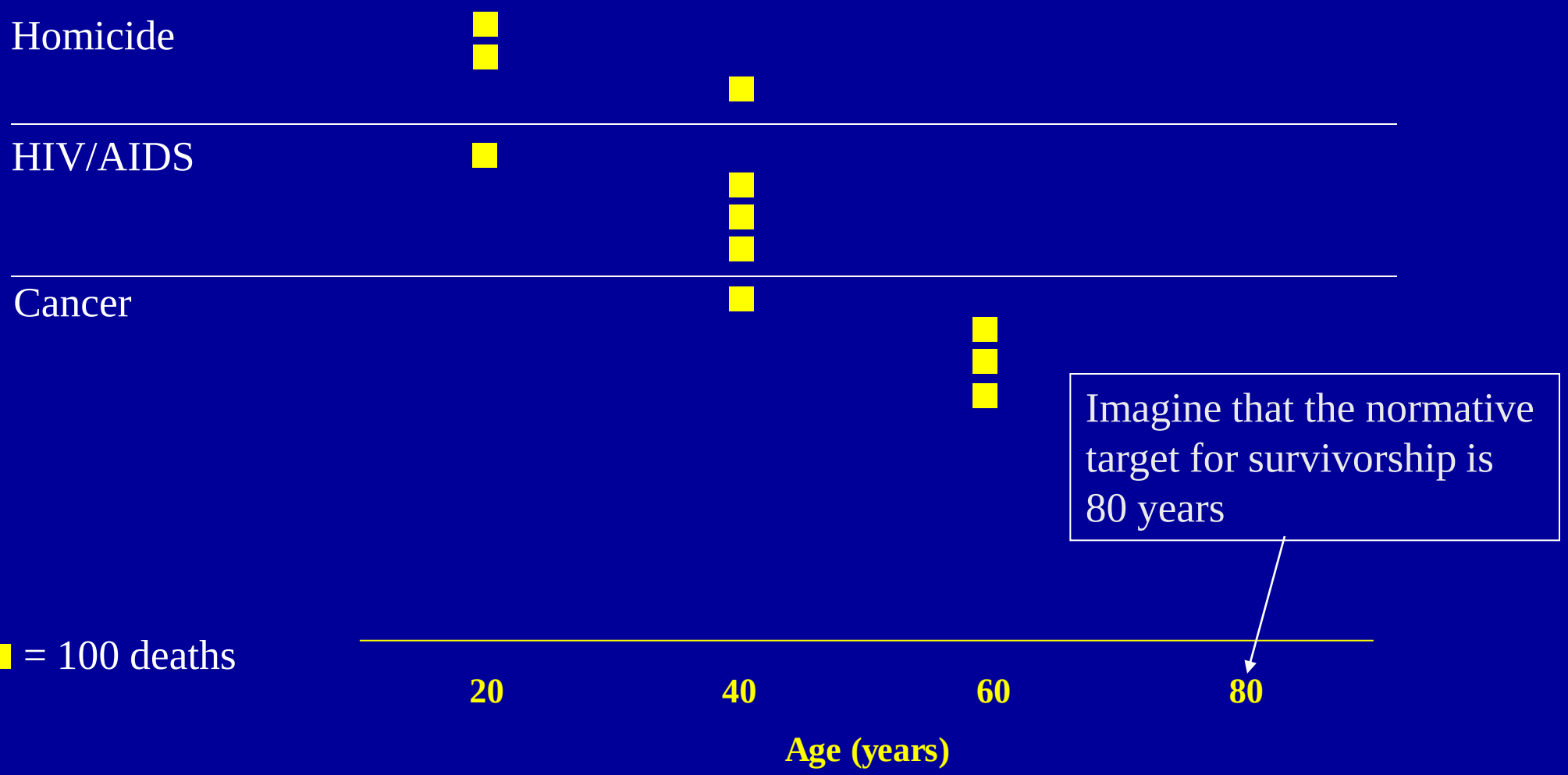
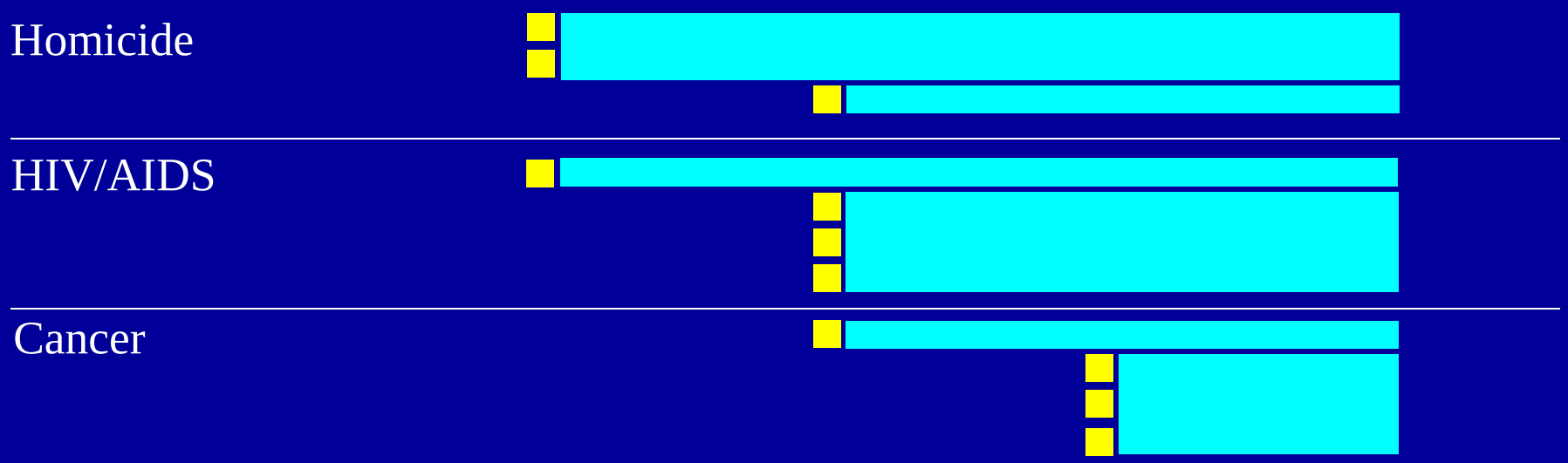
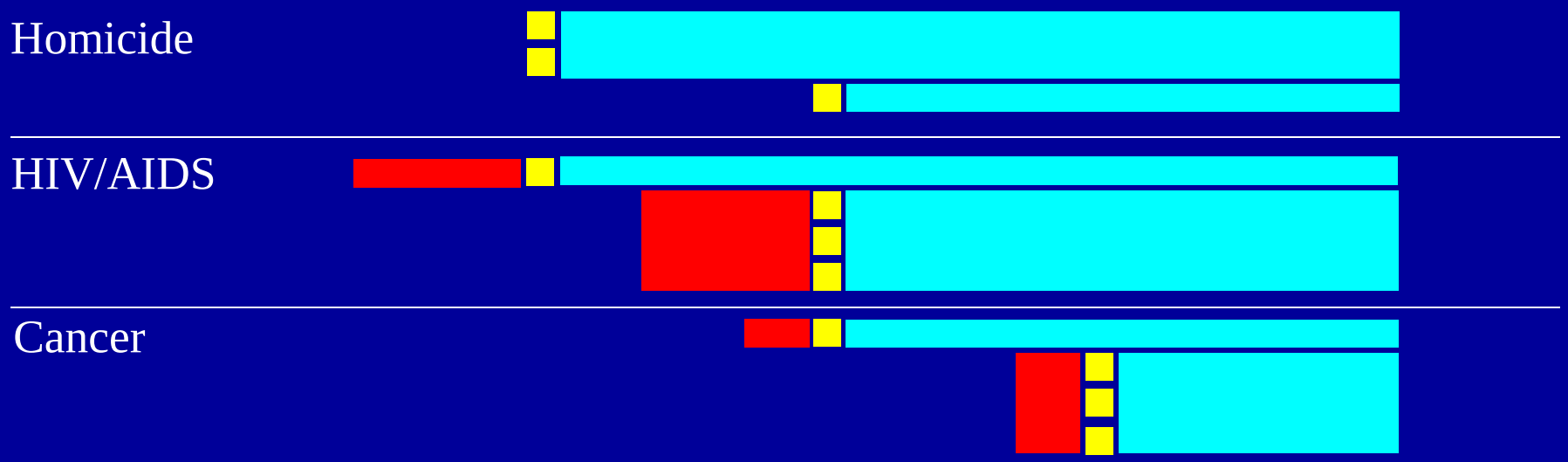
Health gap


Homicide
HIV/AIDS
Cancer
Imagine that the normative target for survivorship is 80 years
■ = 100 deaths
20
40
60
80
Age (years)

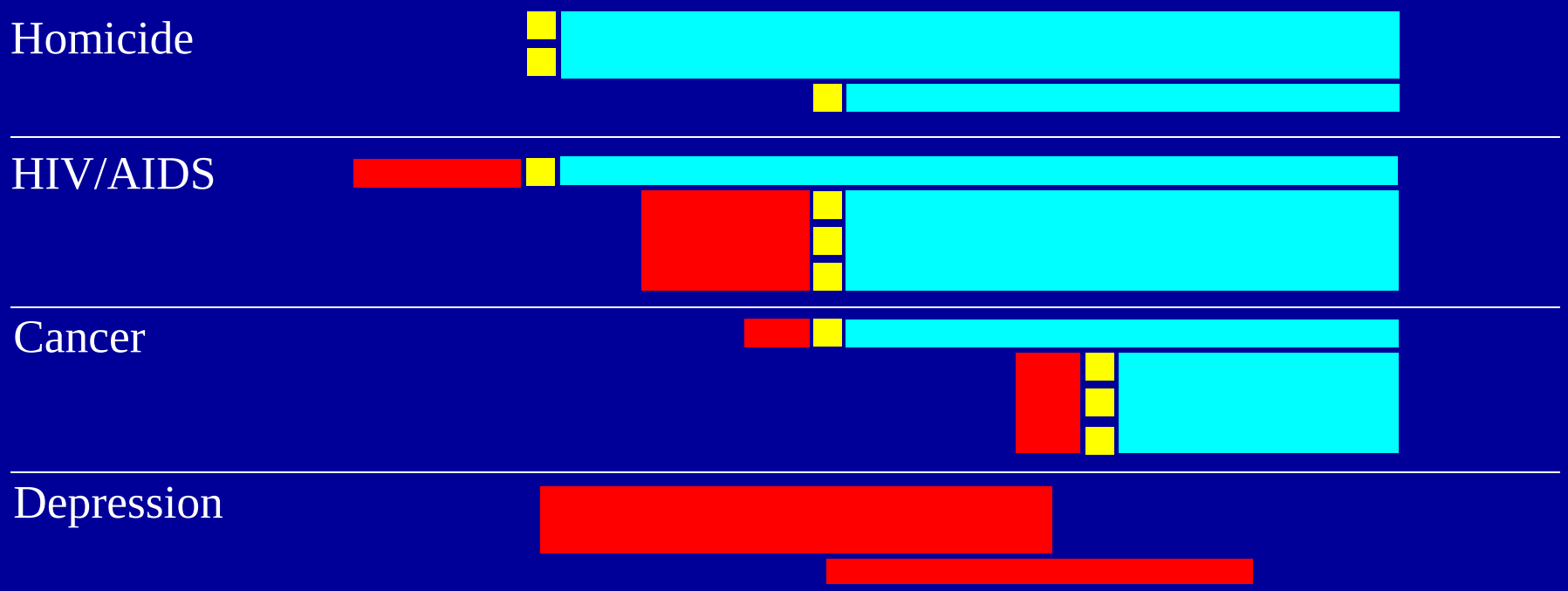
Health gap


Homicide
HIV/AIDS
Cancer
= 100 deaths
Lost years
20
40
60
80
Age (years)

Health gap


Homicide
HIV/AIDS
Cancer
= 100 deaths
Lost years
Years of poor health
20
40
60
80
Age (years)

Health gap


Homicide
HIV/AIDS
Cancer
Depression
= 100 deaths
Lost years
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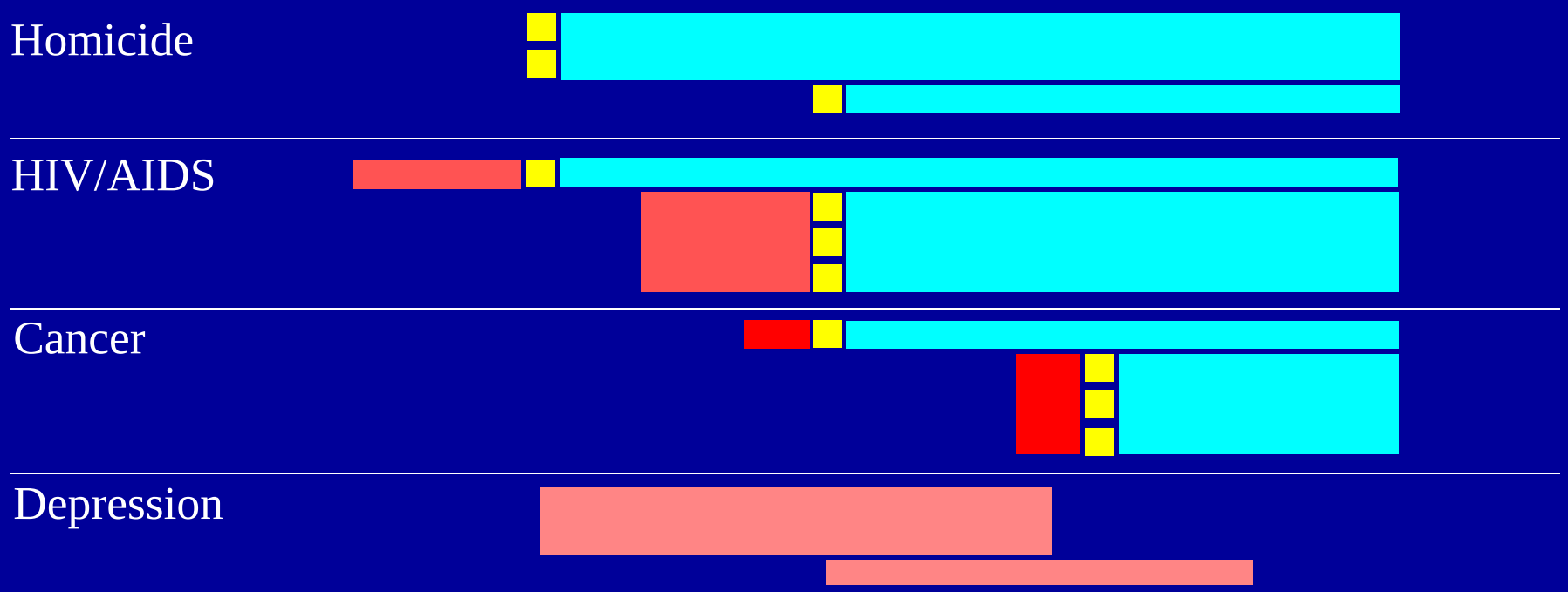
Age (years)

Health gap


Homicide
HIV/AIDS
Cancer
Depression
= 100 deaths
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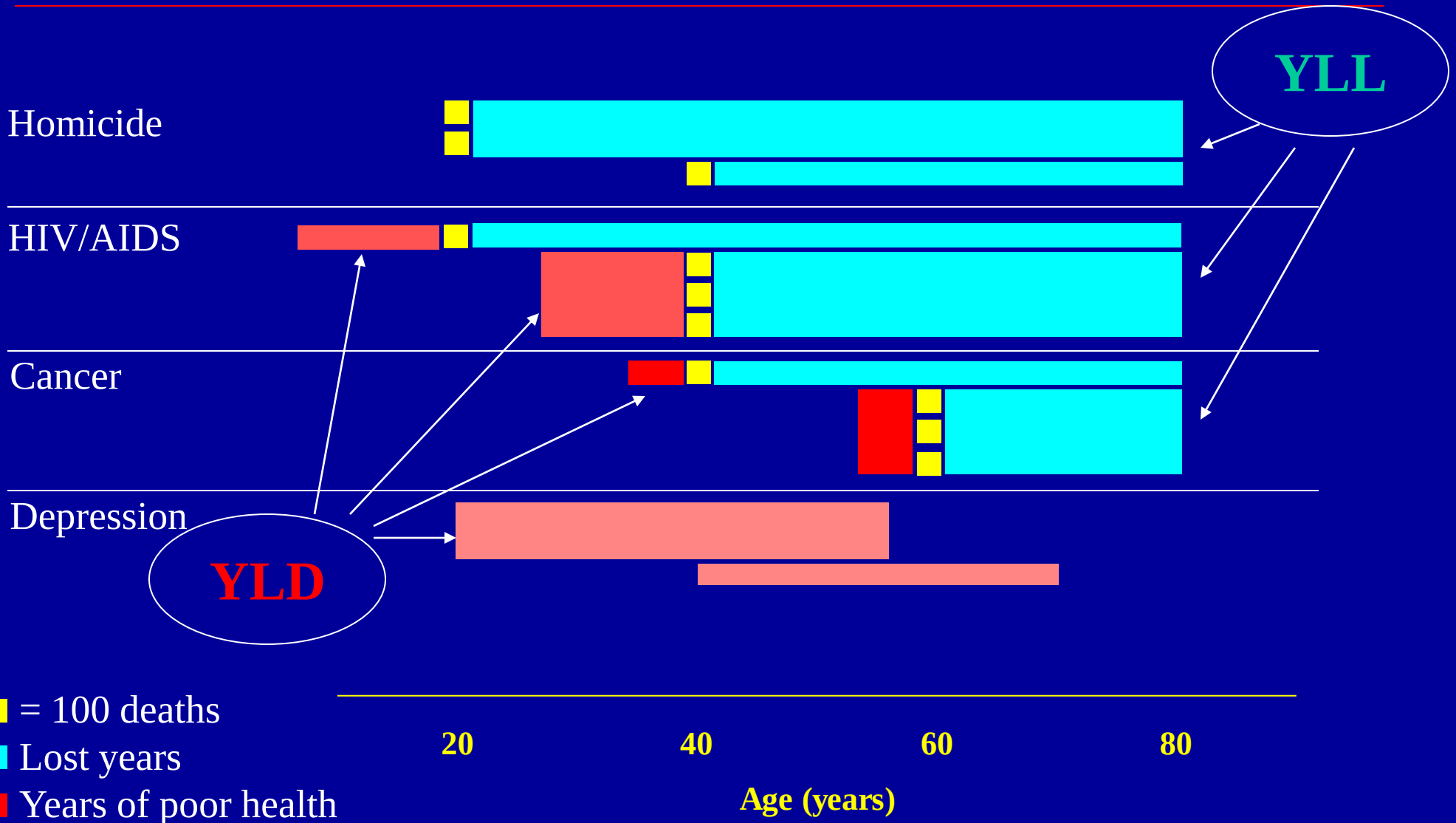
Age (years)

Health gap measures

- Health gaps measure health losses associated with disease or injury
- Example: disability-adjusted life years (DALYs)
- DALY = YLL + YLD
  - years of life lost (YLL) due to premature death
  - years lived with disability (YLD) adjusted for severity
- One DALY represents one lost year of healthy life

Health gap


YLL
Homicide
HIV/AIDS
Cancer
Depression
YLD
= 100 deaths
Lost years
Years of poor health
20
40
60
80
Age (years)

Social value choices in DALYs

- How long ‘should’ people live? Should it differ between men and women?
- How can we compare years of life lost due to premature death with years of life lived with health problems of different severity levels?
- Do years of healthy life have different value at different stages in life?
- Are years of healthy life *now* worth more to society than years of healthy life *in the future*?

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Causal attribution

- *Categorical attribution*

  each event (e.g. a death) is attributed to a single cause according to a defined classification system and set of rules
- *Counterfactual analysis*

  contributions estimated by comparing current levels with expected levels under some alternative scenario

Categorical attribution - 1

- One event, one cause
- “Additive decomposition”: parts sum to 100%
- Cause-of-death tabulations are an example of categorical attribution, following the International Classification of Disease
- With multiple causes, “underlying” cause is assigned, defined as “the disease or injury which initiated the train of morbid events leading directly to death.”

For want of a nail the shoe was lost.
For want of a shoe the horse was lost.
For want of a horse the rider was lost.
For want of a rider the battle was lost.
For want of a battle the kingdom was lost.
And all for the want of a horseshoe nail.

- Nursery rhyme

Categorical attribution - 2

- When multiple causes are in play, which is the "underlying cause"?
- Example:

  A person with diabetes and hypertension has an MI complicated by congestive heart failure and ultimately dies of pneumonia in the ICU.

  ***What is the underlying cause of death* ?**

Categorical attribution - 3

- International Classification of Disease offers limited set of conventions (rules) that are
  - Arbitrary
  - Incomplete
  - Inconsistent
- Examples:
  - TB & HIV coded to **HIV**
  - Diarrheal disease and LRI coded to **LRI**
  - Measles and LRI coded to **measles**
  - Hepatitis B virus and liver cancer coded to **liver cancer**
  - HIV and non-Hodgkin's lymphoma coded to **HIV**

Counterfactual analysis

- How would burden change if a cause were eliminated (or reduced)?
- More realistic, more intuitive (maybe), but contributions don’t naturally sum to 100%
- Challenge in attribution persists due to joint causality

Causal attribution in population-health measures

- *Categorical attribution* is typically used in:
  - Cause of death tabulations
  - Tabulations of health gaps attributed to diseases or injuries
- *Counterfactual analysis* is typically used in:
  - Tabulations of health gaps attributed to risk factors
  - Causal analyses relating to life expectancy or health expectancies

Causal attribution: summary

- Categorical attribution:
  - *Pros*: simple, used widely, additive
  - *Cons*: no recognition of multi-causality

- Counterfactual analysis
  - *Pros*: conceptually clearer, consistent with policy analysis
  - *Cons*: more difficult to compute and explain, multi-causal pathways depend on sequence

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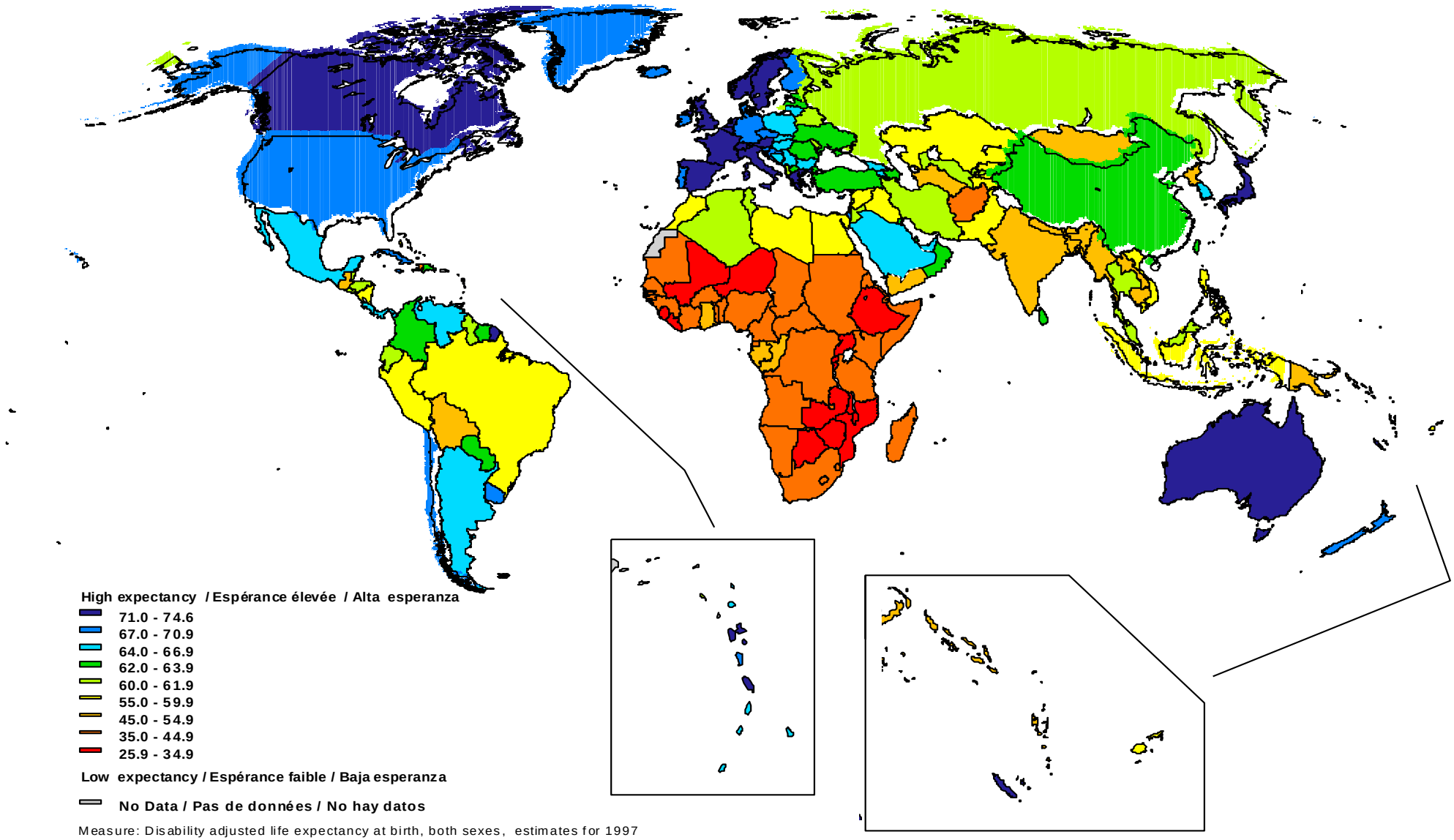
Healthy Life Expectancy

Espérance de vie en santé

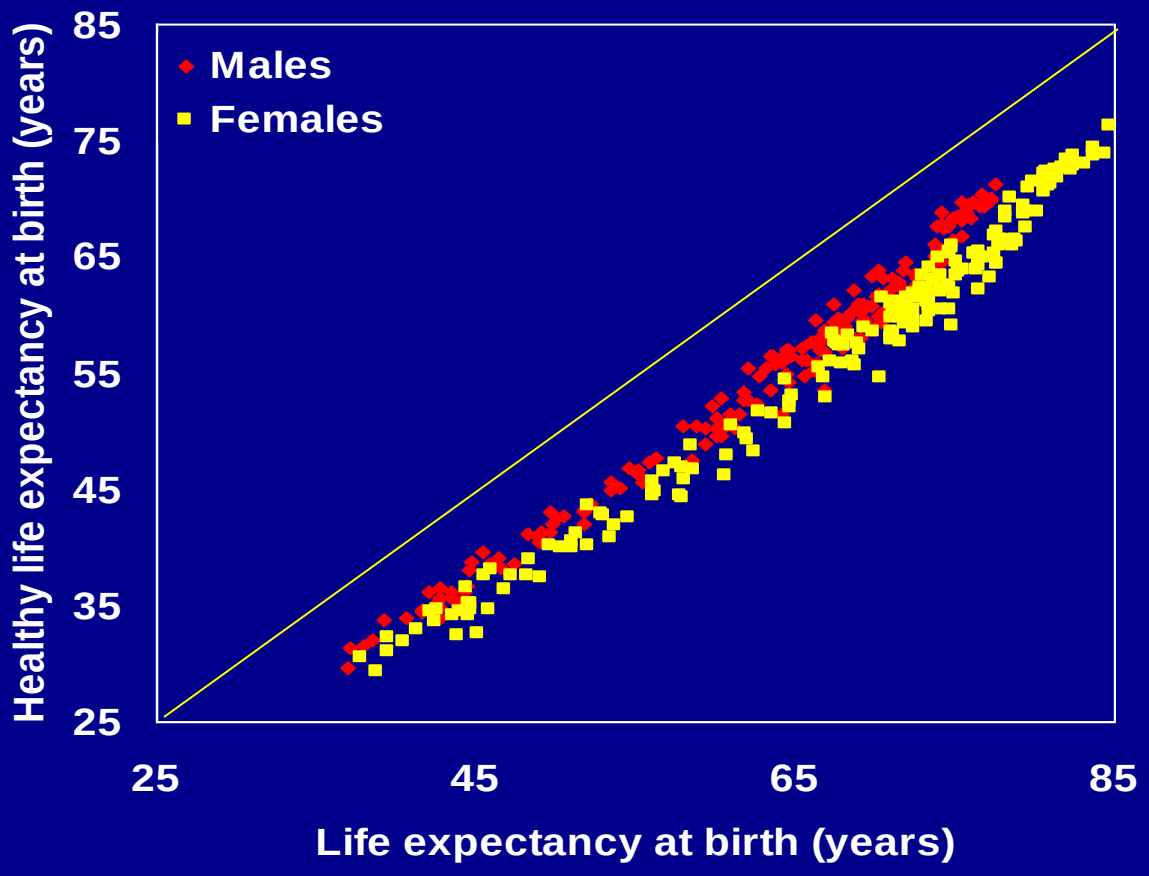
Esperanza de vida saludable



Measure: Disability adjusted life expectancy at birth, both sexes, estimates for 1997
Mesure: Espérance de vie à la naissance corrigée de l'incapacité, population totale, estimations pour 1997
Medida: Esperanza de vida al nacer ajustada por incapacidad, ambos sexos, estimaciones para 1997

Source: World Health Report 2000

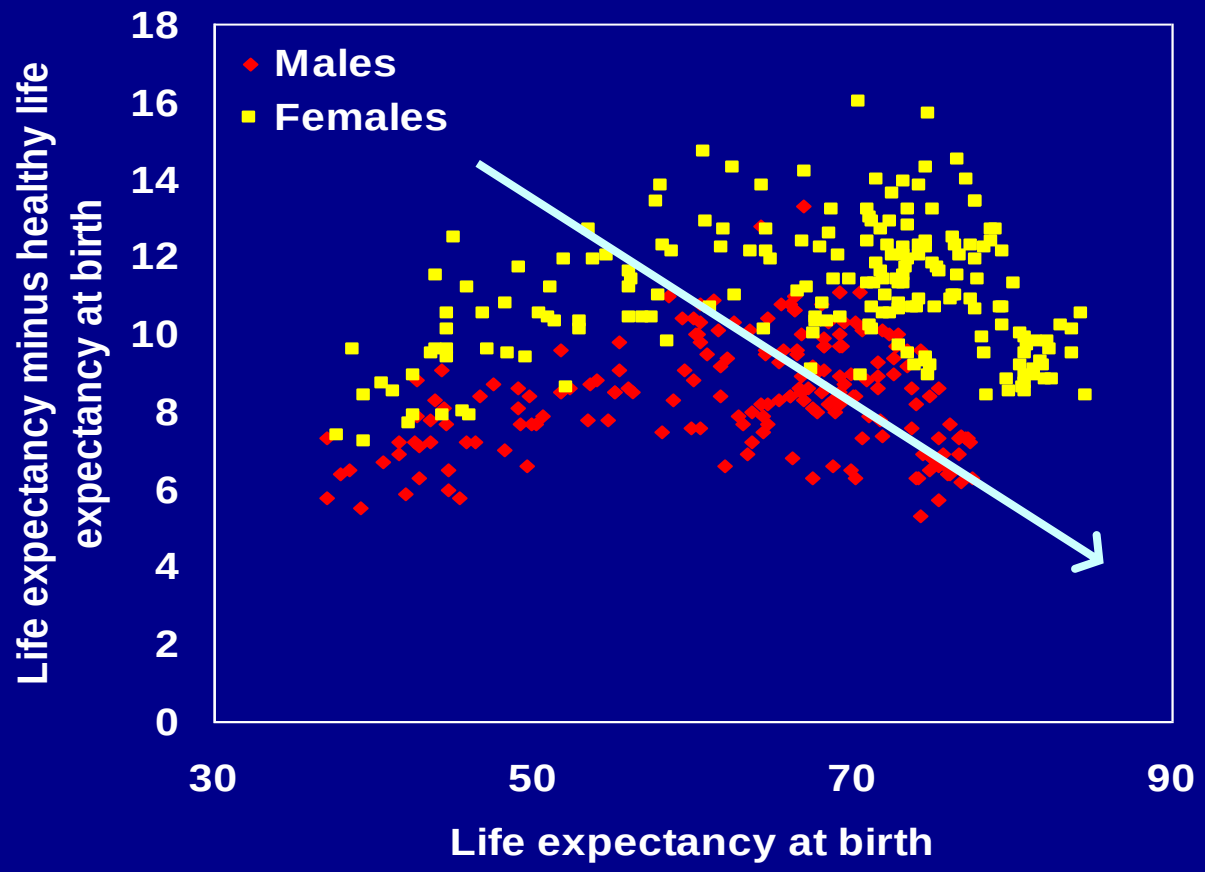
Life expectancy and HALE
191 countries, 2000



Data: World Health Report 2000

Compression of morbidity?

As life expectancy rises… ➔

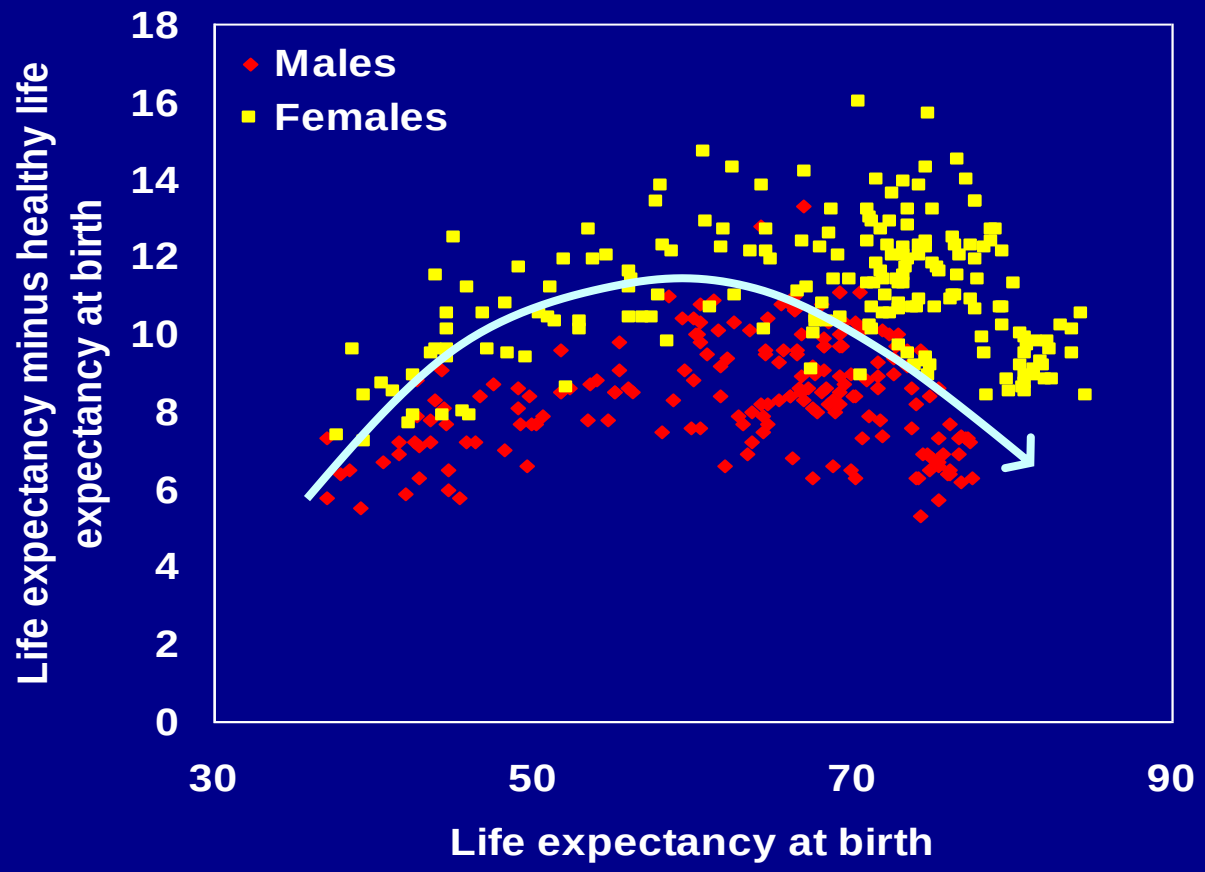


…does disability decline?

Data: World Health Report 2000

Compression of morbidity?

As life expectancy rises… ➔



…does disability decline?

Only past age 60

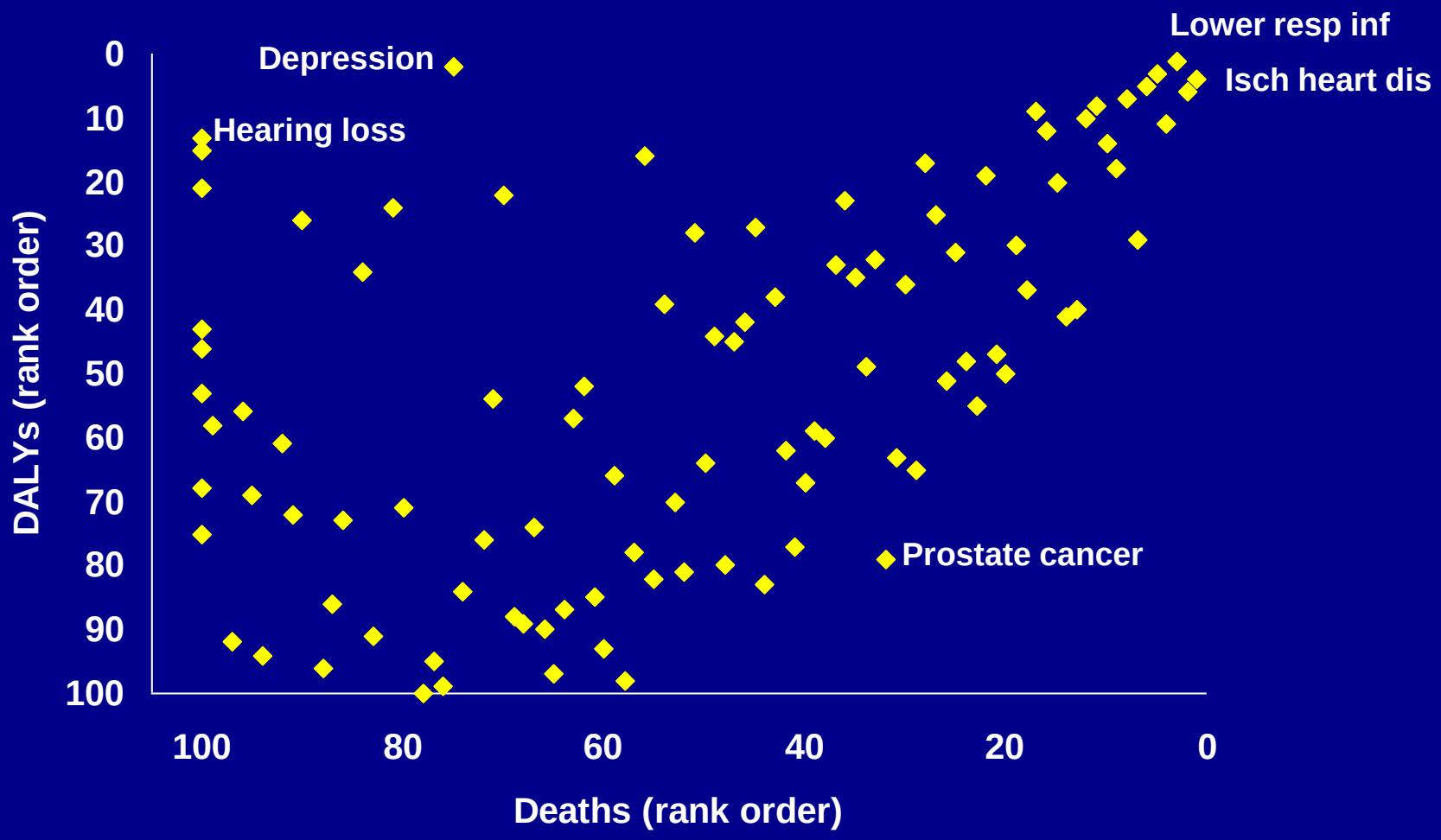
Data: World Health Report 2000

Leading global causes of deaths and DALYs in 2008

Causes of death	Deaths (%)	*Causes of DALYs*	DALYs (%)
Ischaemic heart disease	12.9	Lower respiratory infections	5.4
Cerebrovascular disease	10.2	Depression	4.7
Lower respiratory infections	6.4	HIV / AIDS	4.4
Chron. Obstr. Pulm. Dis.	5.7	Ischemic heart disease	4.4
HIV/AIDS	3.8	Diarrhoeal diseases	3.8
Diarrheal disease	2.9	Cerebrovascular disease	3.3
Lung cancer	2.4	Road traffic accidents	3.1
Road traffic accidents	2.4	Prematurity and low birth wt	2.8
Tuberculosis	2.1	Birth asphyxia and birth trauma	2.6
Prematurity and low birth wt.	1.8	Neonatal infections	2.6

Data: World Health Organization Global Burden of Disease Update, Pub. 2008

Rank order of deaths and DALYs, 2008



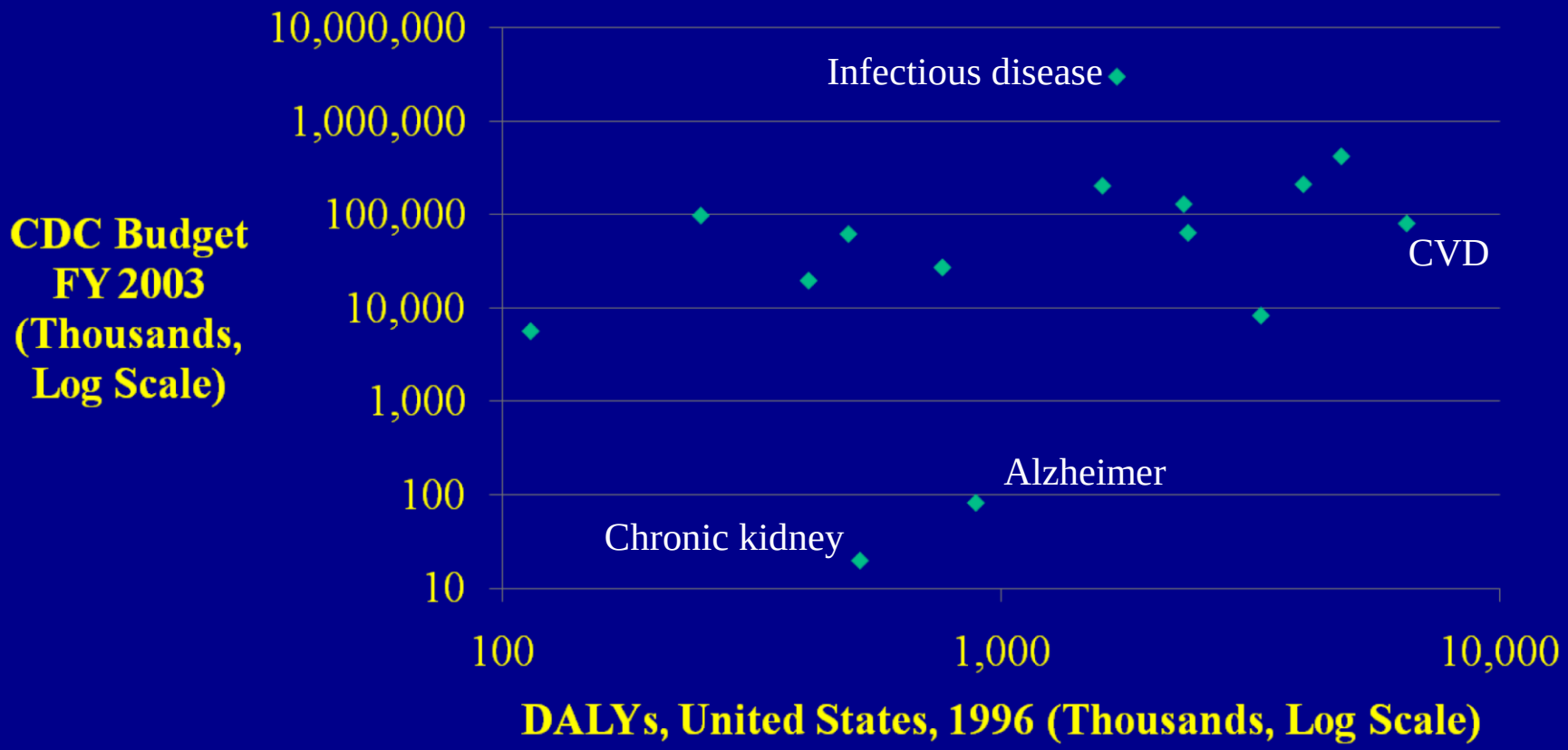
Data: World Health Organization Global Burden of Disease Update, Pub. 2008

Leading causes of burden of disease by income level (2001)

	Low- and middle-income countries				High income countries		
	Cause	*DALYs(3,0) (millions)*	*% of total*		*Cause*	*DALYs(3,0) (millions)*	*% of total*
1	Perinatal conditions	89.07	6.4%	1	Ischaemic heart disease	12.39	8.3%
2	Lower respiratory infections	83.61	6.0%	2	Cerebrovascular disease	9.35	6.3%
3	Ischaemic heart disease	71.88	5.2%	3	Unipolar depressive disorders	8.41	5.6%
4	HIV/AIDS	70.80	5.1%	4	Alzheimer and other dementias	7.47	5.0%
5	Cerebrovascular disease	62.67	4.5%	5	Trachea, bronchus, lung cancers	5.40	3.6%
6	Diarrhoeal diseases	58.70	4.2%	6	Hearing loss, adult onset	5.39	3.6%
7	Unipolar depressive disorders	43.43	3.1%	7	COPD	5.28	3.5%
8	Malaria	39.96	2.9%	8	Diabetes mellitus	4.19	2.8%
9	Tuberculosis	35.87	2.6%	9	Alcohol use disorders	4.17	2.8%
10	COPD	33.45	2.4%	10	Osteoarthritis	3.79	2.5%

Source: Mathers, Lopez & Murray, Chapter 3.of *Global Burden of Disease and Risk Factors*, 2006

Burden of disease and US CDC budget



Curry et al. Am J Prev Med 2006