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Mortality Modelling

Looking through the crystal ball

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Agenda

- Mortality model variants
- Causal models
- Risk Profiling
- Examples of projections
- Other applications

Mortality model variants

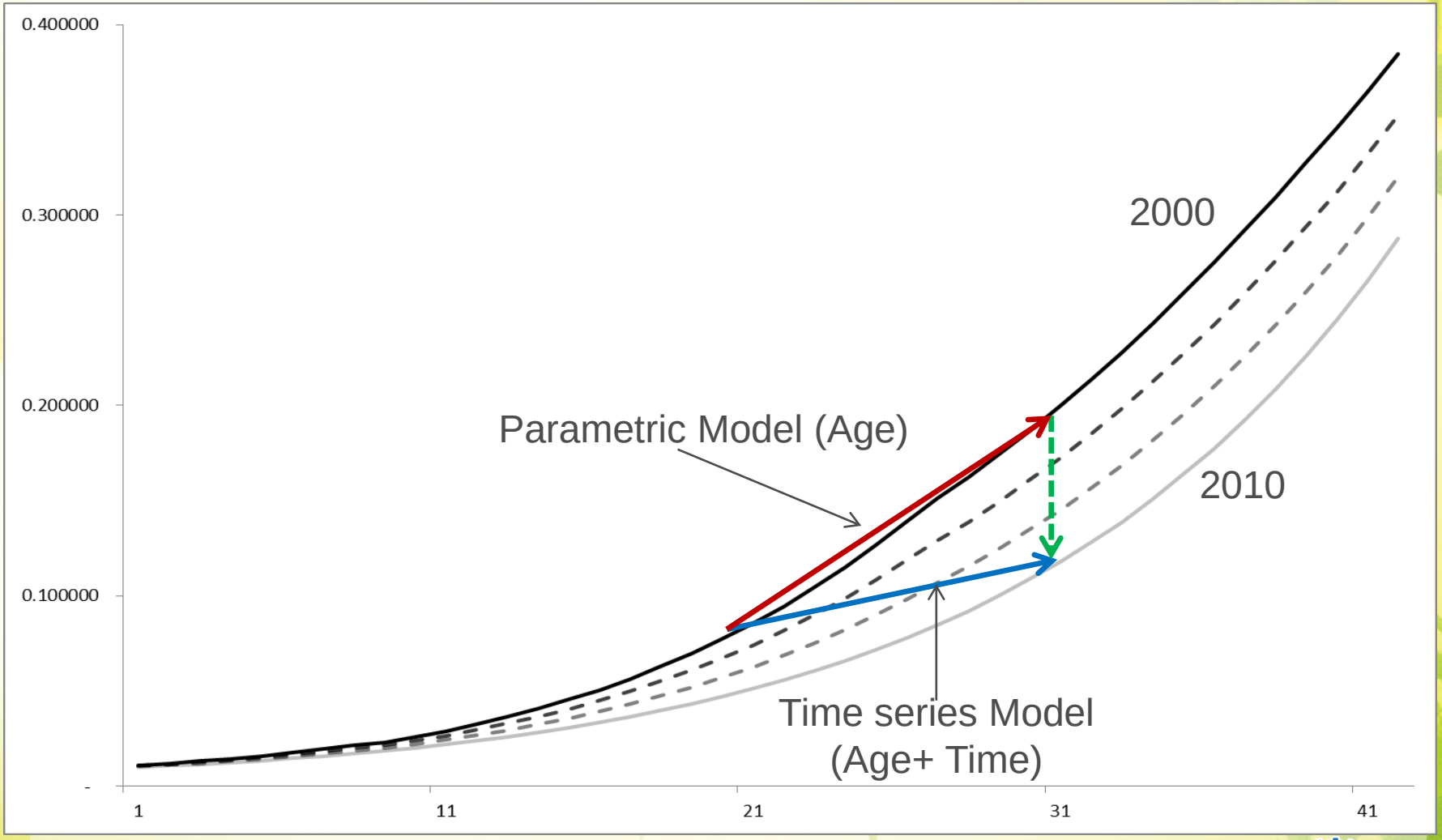
- Parametric models

$$\mu_x = A + Bc^x$$

- Time series models

$$\ln m_{x,t} = a_x + b_x k_t + e_{x,t}$$

Age – Period Effects



Parametric Models

- Usually simple models
- Is a good fit for the shape of mortality by age
- Adjustments possible to include accident hump
- Is static in nature
- No time element and hence mortality improvements not modelled

  … mainly because the need was limited

Time series models

- Models the period as well as the age effect
- Advanced models allow for cohort effect
- Better fit to historical data
- Can be data intensive
- Better for forecasting future mortality (challenge of overfitting)
- Can be very sensitive and hence forecasts may be less robust

Aubrey de Grey

"I think the first person to live to 1,000 might be 60 already"

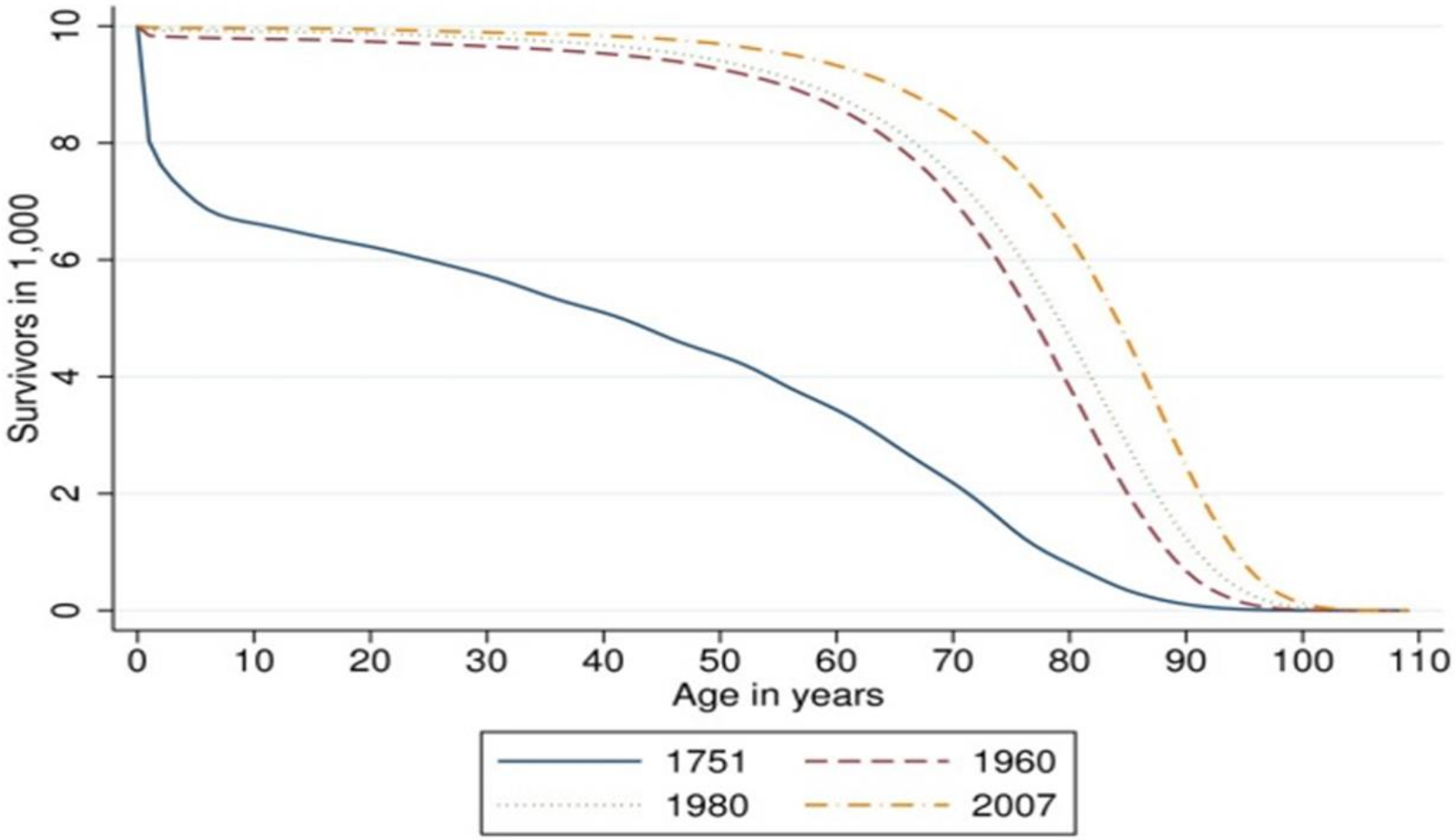
CMI Projection

"What is the life expectancy for a male aged 65 in 2027?"

42

Will we really live to age of 107 on average?

Rectangular survival curve

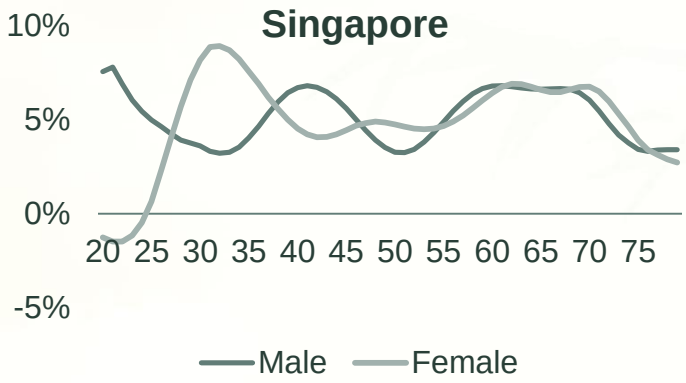


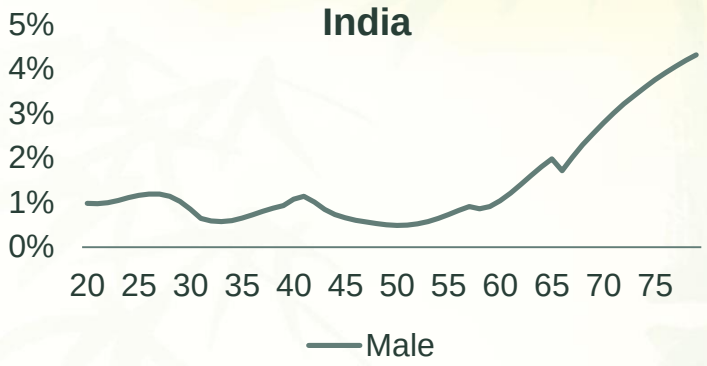
Life expectancy in various countries

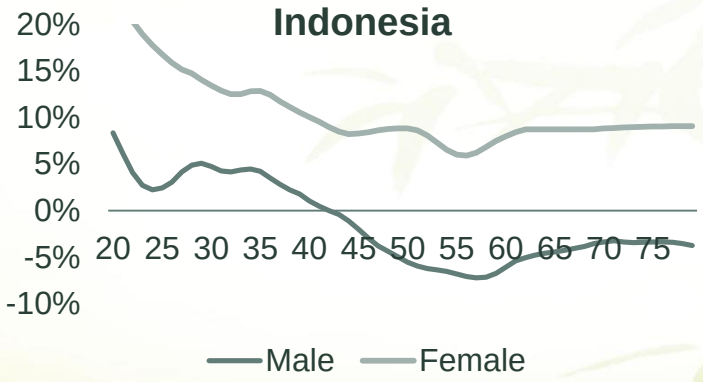
Country	1990	2000	2011
Japan	79	81	83
Singapore	75	79	82
Australia	77	80	82
United Kingdom	76	78	80
United States	75	77	79
China	69	71	76
SriLanka	69	70	75
Malaysia	71	72	74
Thailand	67	69	74
Indonesia	62	65	69
India	58	61	65
Afghanistan	49	55	60
South Africa	63	57	58
Somalia	46	49	50

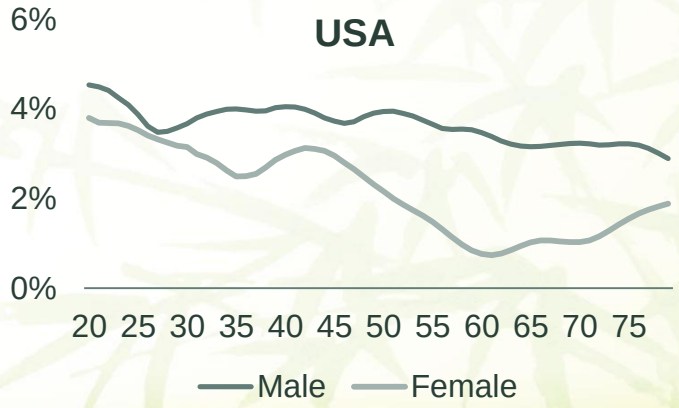
Source: WHO

Mortality improvements in selected countries





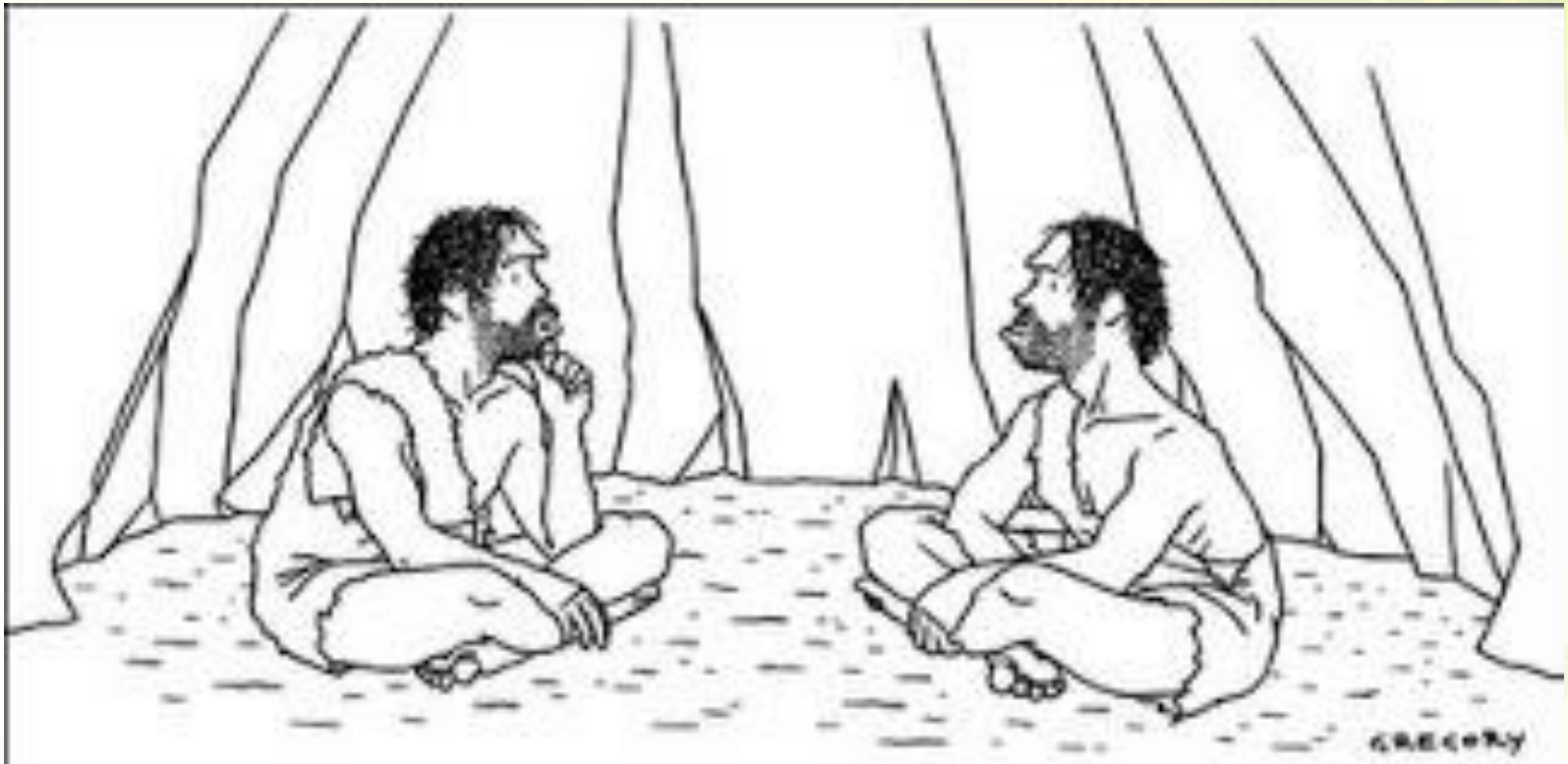




Limitations of the current models

- How will we get to a life expectancy of 107?
- What factors will contribute to the same?
- Is there a possibility that the life expectancy starts reducing?
- How do we explain slowing down of increase in life expectancy in countries with high life expectancy?

What is driving these trends in life expectancy?



"Something's just not right—our air is clean, our water is pure, we all get plenty of exercise, everything we eat is organic and free-range, and yet nobody lives past thirty."

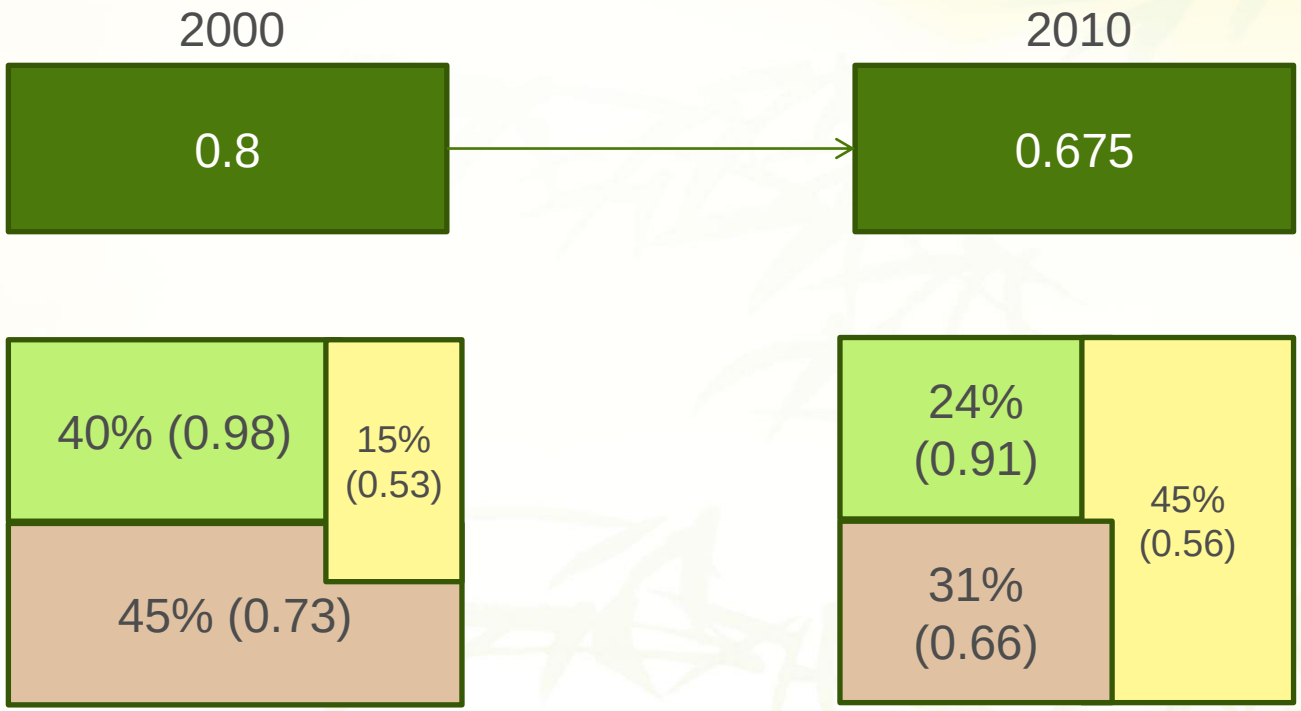
Causal models

- Which are the significant factors that contribute to mortality risk?
- How do they affect mortality rates?
- Can they continue to have the effect that they had in the past?
- If not, then what do we expect in the future?

How do causal models work?

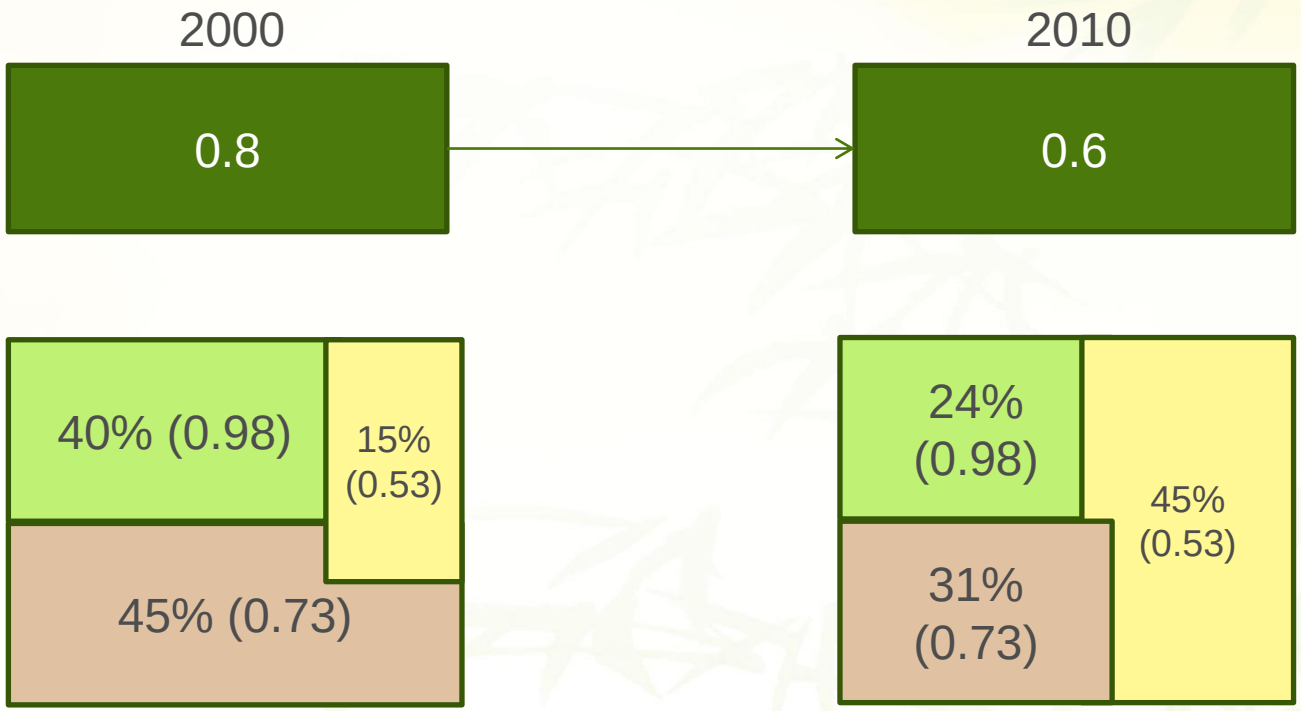
- Individuals move through different risk profiles over their lifetime and hence are exposed to a different mortality or morbidity risk at a given time.
- We model population mortality by accumulating individual mortality risks.

Risk accumulation



The less risky population segment has increased at the cost of more risky population segment

Impact of medical advances



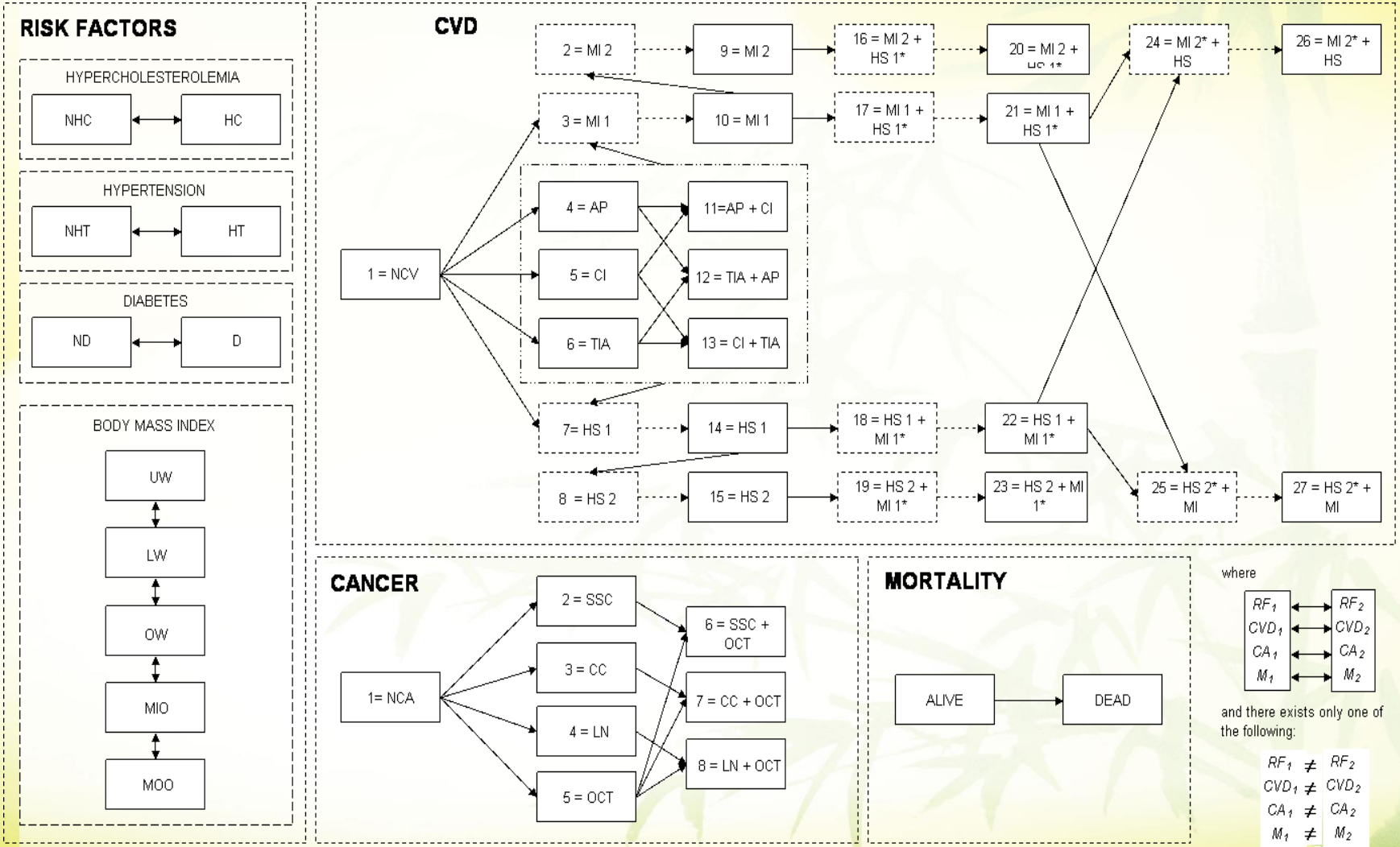
Population segment proportions as well as riskiness of segments will vary in general.

Significant factors affecting mortality

Personal factors	Medical Conditions	Medical Events
• Age • Gender • Smoking • Genetic makeup !!! • Environmental factors	• Obesity • High Blood Pressure • High Cholesterol • Diabetes	• Heart Attack • Stroke • Cancer • Kidney Failure

Already captured in underwriting data !!!

Example of a causal model



Source: Towers Watson

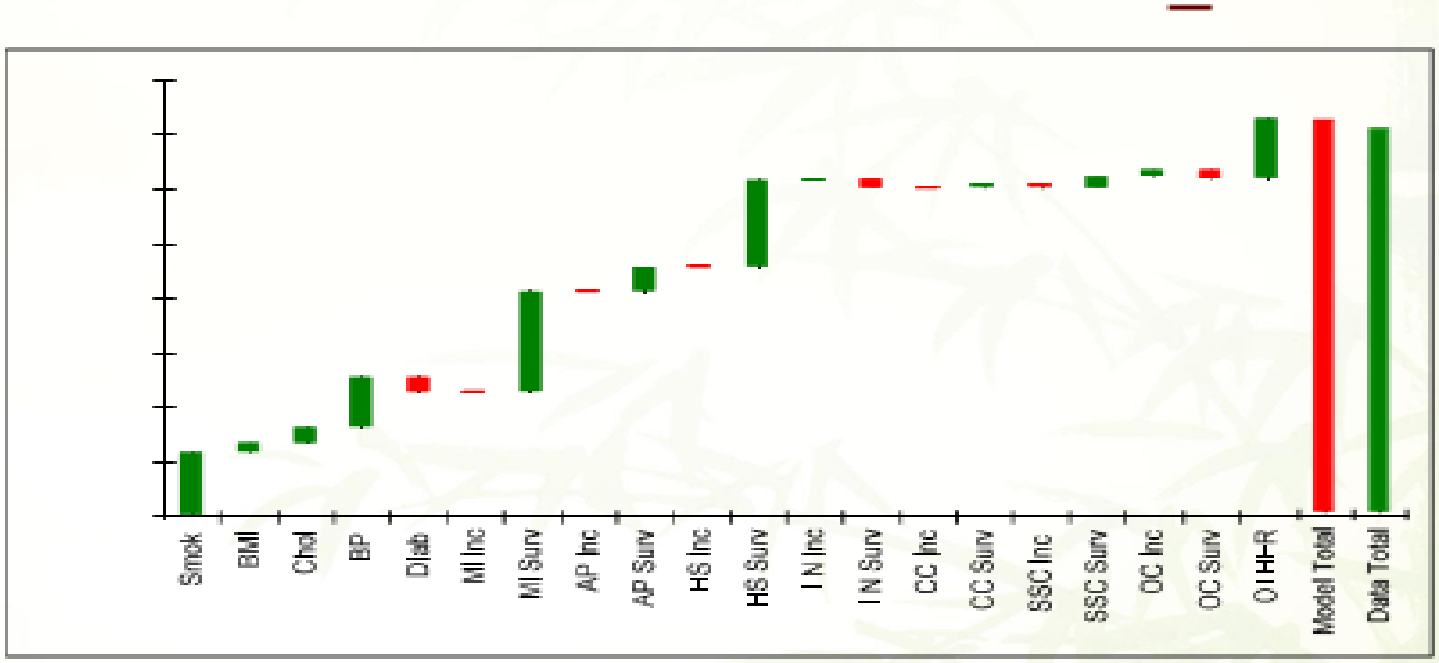
Relative risks of death from different risk profiles

Table 4.21: Parameters for the model for mortality.

Factor	Parameters
Intercept	−5.9281
Age	−0.01475
Age^2	0.0007460
Sex: Female	−0.4099
Smoking: Ex	0.1455
Current	0.5689
BMI : Lightweight	−1.7760
Overweight	−2.5030
Moderately Obese	−3.3130
Morbidly Obese	−3.5640
Age × BMI: Age × Lightweight	0.01585
Age × Overweight	0.02248
Age × Moderately Obese	0.03635
Age × Morbidly Obese	0.04252

Source: Heriot Watt University

What caused mortality improvements?



Source: UK Actuarial Profession / Towers Watson

High Blood Pressure

Hypertension is associated with increased mortality mainly due to stroke and other cardiovascular diseases. Both systolic and diastolic blood pressures are associated with stroke mortality. Hart et al. (1999).

Over a 25 year period, the relative risk of all cause mortality for hypertensive patients (defined as a systolic blood pressure of 160 mm Hg or greater, a diastolic blood pressure of 95 mm Hg or greater, or both) was 2.13. Van Den Hoogen et al. (2000)

Population mix - Hypertension

	UK	Japan	US
1980		48.2%	
1991	50.1%	46.4%	31.4%
1993	49.3%	44.8%	
1998	43.8%	43.2%	
1999		42.9%	38%
2006	36.0%	37.7%	
2007	40.0%	38.0%	39.6%
2008	40.0%	36.6%	
2009	35.6%	36.8%	39.1%

Source: WHO

Health – landscape is changing

- Individual lifestyle have changed for the better
  - More exercise
  - Aware of illnesses
  - Regular health check-up
- Healthcare industry has changed
  - Increased access to healthcare
  - Increased access to new medical developments
  - Health insurance provision by employers
- Individual lifestyles have changed for the worse as well
  - More stress
  - Sedentary lifestyle
  - Eating out

How do you allow for these and other insights into future predictions?

Advantages of causal models

- Provides more granular insights into the drivers of mortality improvements
- Helps in better projection of future mortality trends
- Provides limiting distribution for future trends
- Help predict potential future impact of current medical developments
- Provides scenarios in which the improvement can turn into deterioration

Impact of quitting smoking

Starting at age 20	Male	Female
Never Smokes	58.6	62.4
Gives up at age 30	57.2	61.2
Gives up at age 50	55.8	60.2
Gives up at age 70	52.7	57.8
Always smokes	51.5	56.1

Source: Towers Watson

Mortality impact of polypill

"…would prevent 88% of heart attacks and 80% of strokes."

	Male	Female
55 year old non smoker	3.3	3.2
70 year old non smoker	2.2	2.0

Source: Towers Watson

Impact of cancer drug

Assuming that all cancers can be cured immediately on detection and no one dies from any form of cancer

	Male	Female
55 year old smoker	3.3	3.2
70 year old smoker	2.2	2.0

Source: Towers Watson

Obesity / Diabetes epidemic

The rate we're going, obesity-related diabetes alone "will break the bank of our healthcare system."

Associated with this weight gain are increased risks in adulthood for joint problems, angina, high blood pressure, heart attacks, strokes, type 2 diabetes and, ultimately, premature death

According to the surgeon general, obesity today is officially an epidemic

The rising tide of diabetes, fuelled by the global obesity epidemic, is very worrying, and particularly in view of the anticipated increase of cardiovascular disease and deaths associated with diabetes

Globally, type 2 diabetes is an enormous problem. In almost every region of the world the prevalence of diabetes is increasing, and by 2030 it's estimated that about 350 million people worldwide will be living with diabetes

Limitations of causal models

- Data intensive to calibrate
- Required data may not be available
- Complex especially if multiple risk factors are built
- Subjective adjustment to historical data (confounding factors)

Additional applications

- Projecting morbidity trends
- Determining underwriting loadings
- Validating results from medical studies for use in actuarial projections
- Adapting trends from one country to another

Morbidity impact of polypill

"…would prevent 88% of heart attacks and 80% of strokes."

	Male	Female
55 year old non smoker	6.2	5.9
70 year old non smoker	2.6	2.7

Source: Towers Watson

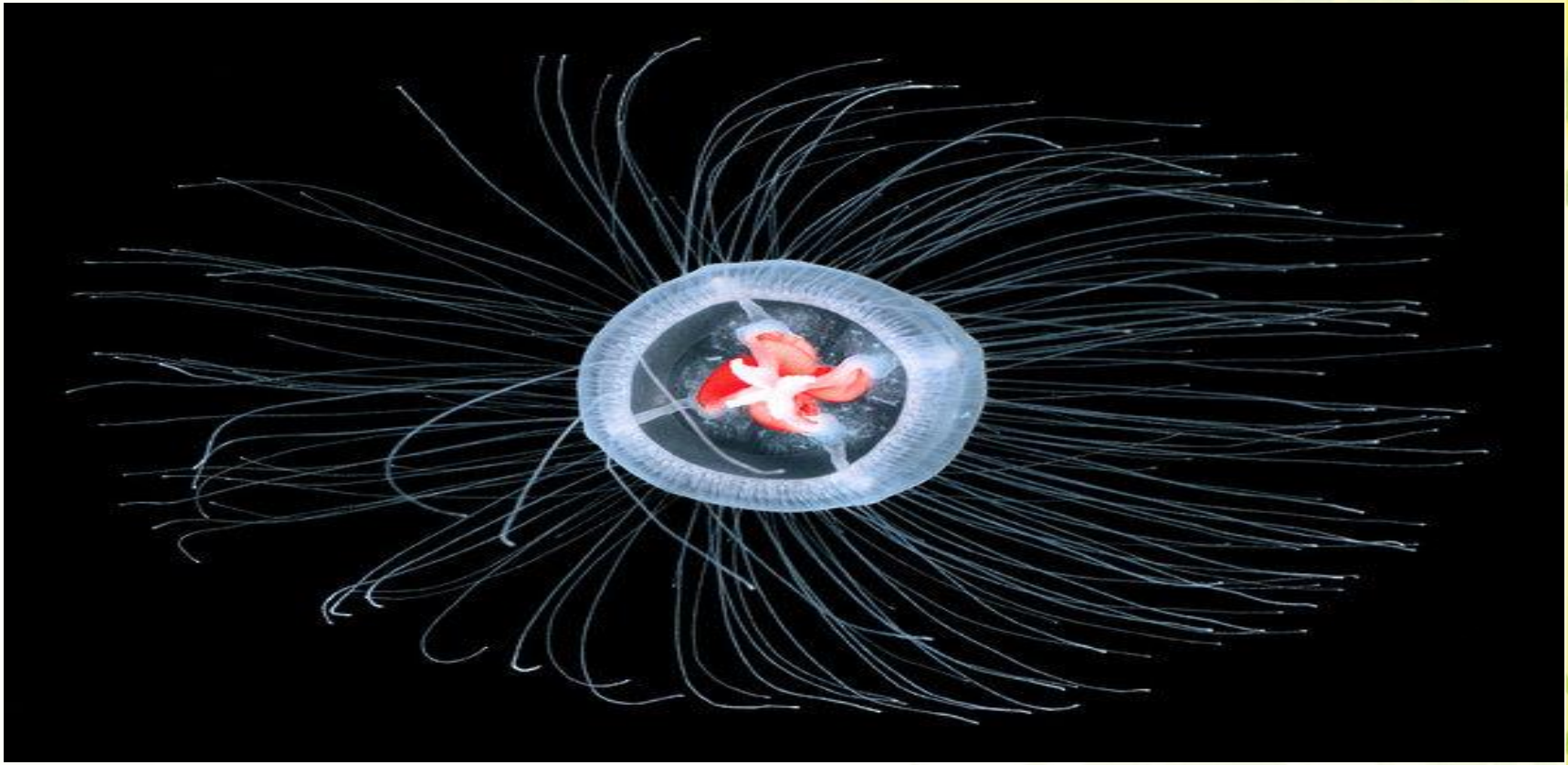
Mortality for a particular profile

Risk Factor	'Superlife'
BP	Low
BMI	Normal
Smoker status	No
Cholesterol	Low
Diabetes	No
Cancer	No
Heart attack	No
Stroke	No

Extra life compared to average	Male	Female
55 year old	1.7	1.2
70 year old	1.9	1.6

Source: Towers Watson

Immortal Jellyfish



Will humans ever get there?

Conclusion

Questions?

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