The Actuarial Profession
making financial sense of the future

Did Methuselah Need Long-Term Care ?
(Will we ?)

Ageing - from the dawn of history until the end of days

Eli Friedwald & Garth Lane

The Dawn of History

Biblical Data

Genesis Ch 5 etc…

“And Adam lived 130 years … and begat Seth”

“And all the years that Adam lived were 930 years”

Biblical Chronology

Name	Date of Birth	Lifespan	Phase
Adam	0	930	1
Seth	130	912	1
Enosh	235	905	1
Keinan	325	910	1
Mahalalel	395	895	1
Yered	460	962	1
Methuselah	**687**	**969**	**1**
Lemech	874	777	1
Noah	1056	950	1

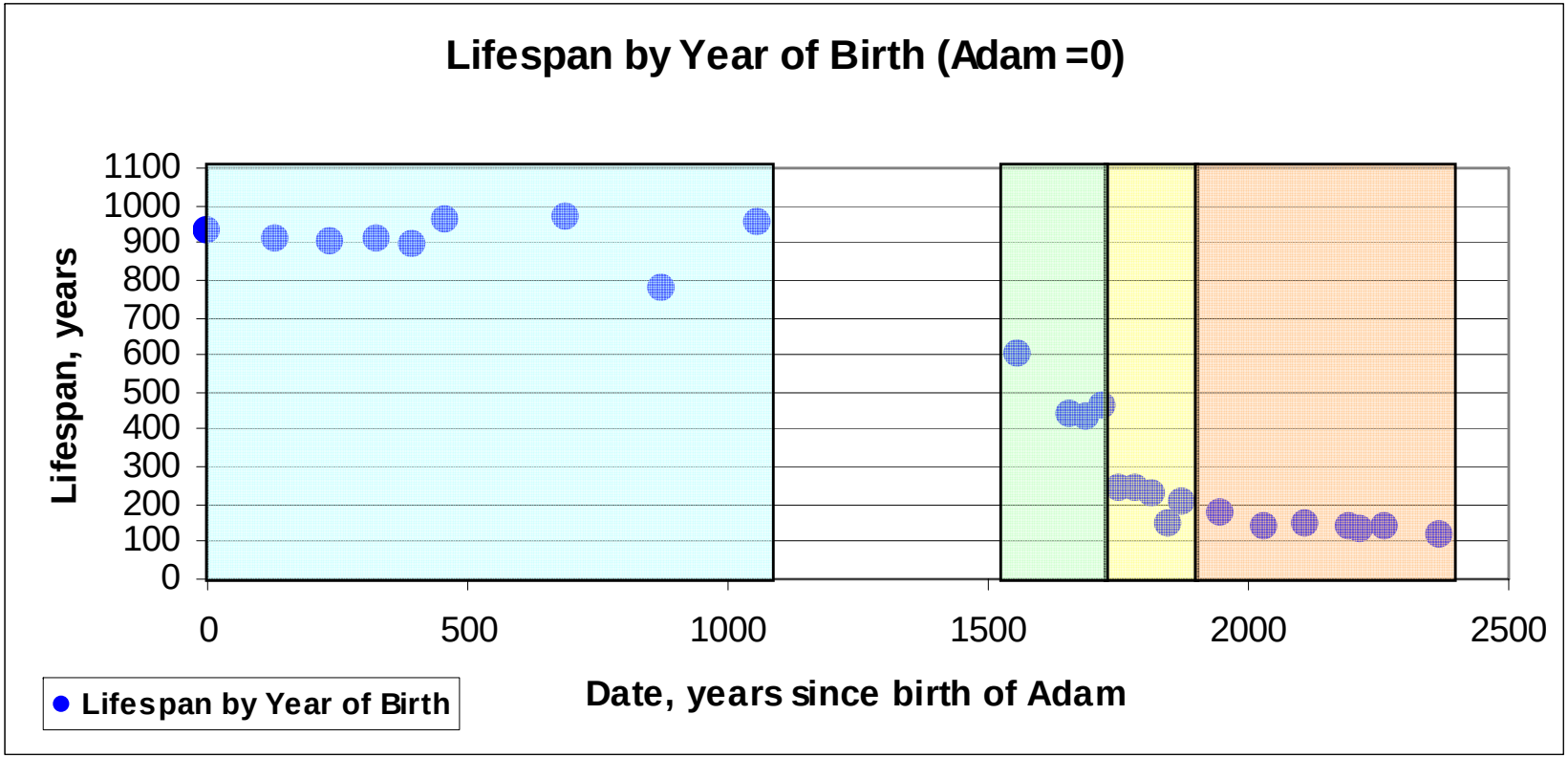
Biblical Chronology

Name	Date of Birth	Lifespan	Phase
Shem	1556	600	1 / 2
Arpachshad	1656	438	2
Shelach	1691	433	2
Ever	1721	464	2

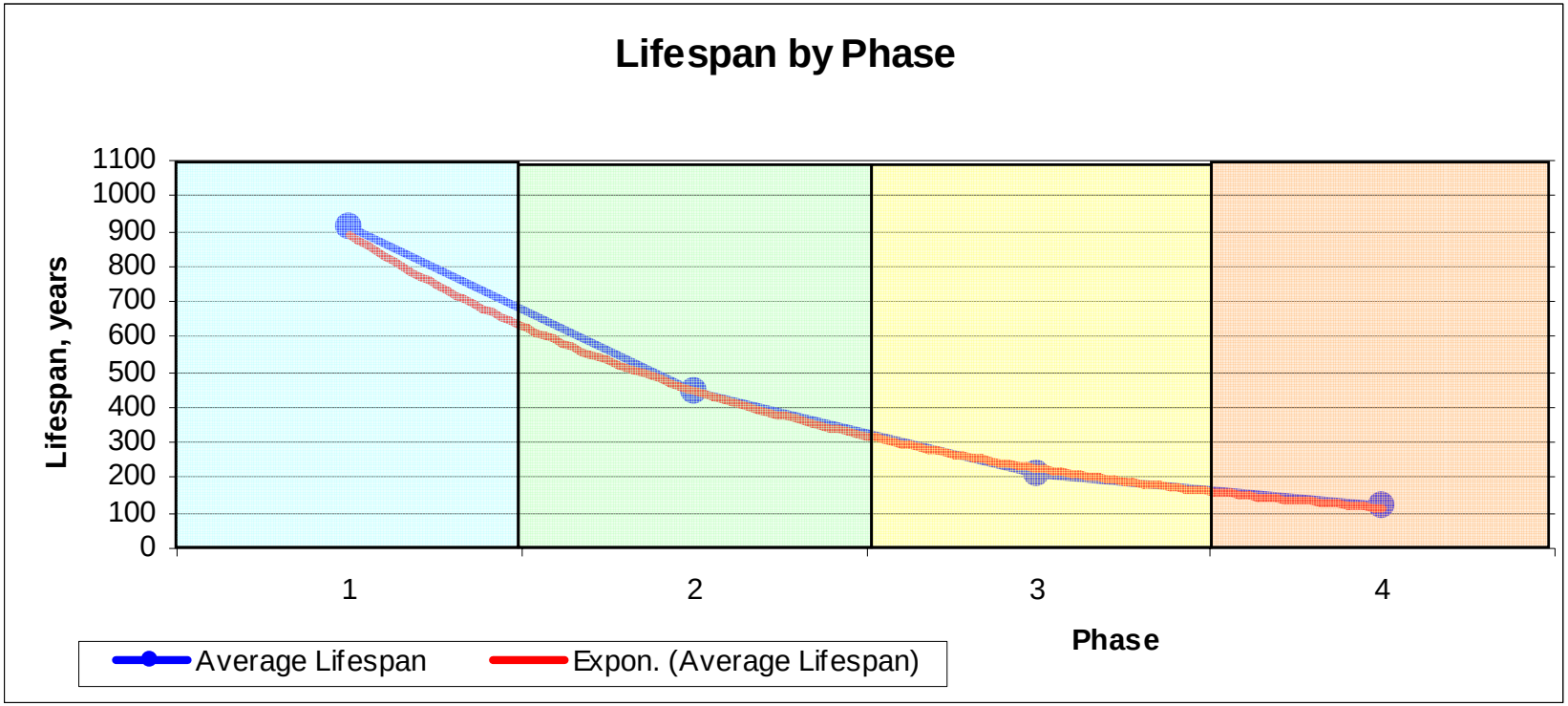
Biblical Chronology

Name	Date of Birth	Lifespan	Phase
Peleg	1755	239	3
Reu	1785	239	3
Serug	1817	230	3
Nahor	1847	148	3
Terach	1876	205	3
Abraham	1948	175	3 / 4
Ishmael	2032	137	3 / 4
Jacob	2108	147	3 / 4
Levi	2195	137	3 / 4
Kehath	2215	133	3 / 4
Amram	2261	137	3 / 4
Moses	2368	120	4

Chart of Biblical Lifespans



Biblical Lifespan by Phase



Declining Longevity - Hypotheses

Environmental

- Increasing atmospheric penetration of UV
- Diet (meat eating), toxins

Biological

- Genetic mutations

Biblical Lifespans

120 = 70 ?

Genesis 6:3

"..he is only flesh, therefore his days shall be 120 years"

Psalms 90

" The days of our life are but 70 years and if with strength, 80 years.."

120 years = Maximum attainable (terminal age)
70 / 80 years = current average

Biblical Legend

In early history, death was near instantaneous, not preceded by illness. (Suggestive of organ failure at terminal age)

But did Methuselah need LTC ??

Age at Giving Birth

Expressed as % of Lifespan

	Minimum	**Average**	**Maximum**
Biblical	7%	18%	53%
Today *	10%	25%	58%

* Based on Lifespan 120, minimum 12, maximum 70

Suggests slower, but proportional maturation to today !!

Conclusions on Methuselah

	Period (yrs) spent in life phases				
	Child	**Teen**	**Middle Age**	**Old**	**LTC**
Today	12	7	40	40	21
Methuselah	96	56	320	320	**168 or 0***

Based on full lifespan of 120 today; 960 Methuselah
* Possibly 0, if Biblical legend is to be believed !

Poor Methuselah !!

Questions Arising – from Methuselah

1. Why did he live so long ?
   - *Theories of Ageing*

2. How long did he spend disabled ?

   168 years or 0 years – or in-between ?
   - *Compression / Expansion of Morbidity*

Theories of Ageing – Explanation or Clue?

- Evolutionary theories
- Gene regulation
- Cellular senescence
- Chemical damage
- Reliability theory
- Neuro-endocrine-immunological theories

Theories of Ageing

- Antagonistic Pleiotropy
- Telomere shortening
- Oxidation and anti-oxidants

Back to the Present

Question

In the current era of mortality improvements, are the additional years of life expectancy :-

(a) Years of good health ?

Or

(b) Years of disability ?

Theories of Increasing Life Expectancy

1. Expansion of Morbidity

2. Compression of Morbidity

3. Dynamic equilibrium

Expansion of Morbidity

Consequences

- Period of life spent in disability increases
- Prevalence of disability increases

Drivers

- Medicine delays end-stage / fatal outcomes
- Incidence and progression pattern of diseases largely unchanged

Not in accordance with known facts !

Compression of Morbidity

Consequences

- Period of life spent in disability decreases
- Prevalence of disability decreases
- Ultimate form is ‘natural death’ (Fries 1980)
  - cf Biblical legend

Drivers

- Medicine delays onset and progression of disabling conditions toward end of life

Not in accordance with known facts !

Dynamic Equilibrium

Consequences

- Period of life spent severely disabled decreases
- Period of life spent lightly disabled increases

Drivers

- Medicine delays disease progression from less severe to severe.
- Medicine delays onset of diseases

Measuring periods of life expectancy

$$l_x = l_x^{healthy} + l_x^{disabled}$$

$$e_x = \frac{\sum_y l_y}{l_x}$$

$$e_x^{healthy} = \frac{\sum_y l_y^{healthy}}{l_x} \qquad e_x^{disabled} = \frac{\sum_y l_y^{disabled}}{l_x}$$

Examples of Life Expectancy

Realistic Example

Male Age 65

Scenario	e_x	$e_x^{healthy}$	$e_x^{disabled}$	**% *disabled***
Base	20	15.0	5.0	25.0%
A	22	16.8	5.2	23.6%
B	22	15.5	6.5	29.5%
C	22	18.0	4.0	18.2%

A = Absolute expansion + relative compression

B = Absolute expansion + relative expansion

C = Absolute compression + relative compression

Compression/ Expansion – The verdict

Evidence is mixed

- Different for different territories
- Different for different studies

Measurement is complicated by different measures of disability between studies

- Data from US is suggestive of dynamic equilibrium, less clear for UK

Explaining International Differences

Robine and Michel (2004) – Staging hypothesis

- Increase in survival rates leads to initial expansion of morbidity
- Improved control of disease progression leads to dynamic equilibrium
- Improved health and behaviours in more recent elderly cohorts leads to compression of morbidity
- Gradual emergence of very old and frail population leads to new expansion of morbidity

But this is controversial !

Modern Longevity Ideals

- Careful of “Shangri La” legends
- Real world examples
- Hunza Valley
- Okinawa
- Sardinia
- Brief look at factors influencing Longevity
- More importantly – Health in old age

Hunza Valley

- Mountainous valley near Gilgit – Pakistan
- Elevation of 2,438 metres (7,999 feet)
- Literacy believed to be above 90%
- Oldest ages reported end in 0 or 5 – Guesses?
- Fit, full of vitality and virtually free from disease
- Extension of Life – Compression of Morbidity

Okinawa

- Okinawa Centenarian Study
- http://okicent.org/study.html
- Concentration of Centenarians (2x USA)
- 80% lower heart disease
- 80% less breast/prostate and 50% less ovarian and colon cancer
- 48% less hip fractures than Americans

Quality of Life in these Populations

- Extremely fit – exercise and work into old age
- Centenarian Okinawans still farming
- 80 year olds climbing mountains in Pakistan
- Psychosocial environment important
- Remarkable health
- Rapid terminal decline

Genetic Heritage as a Factor

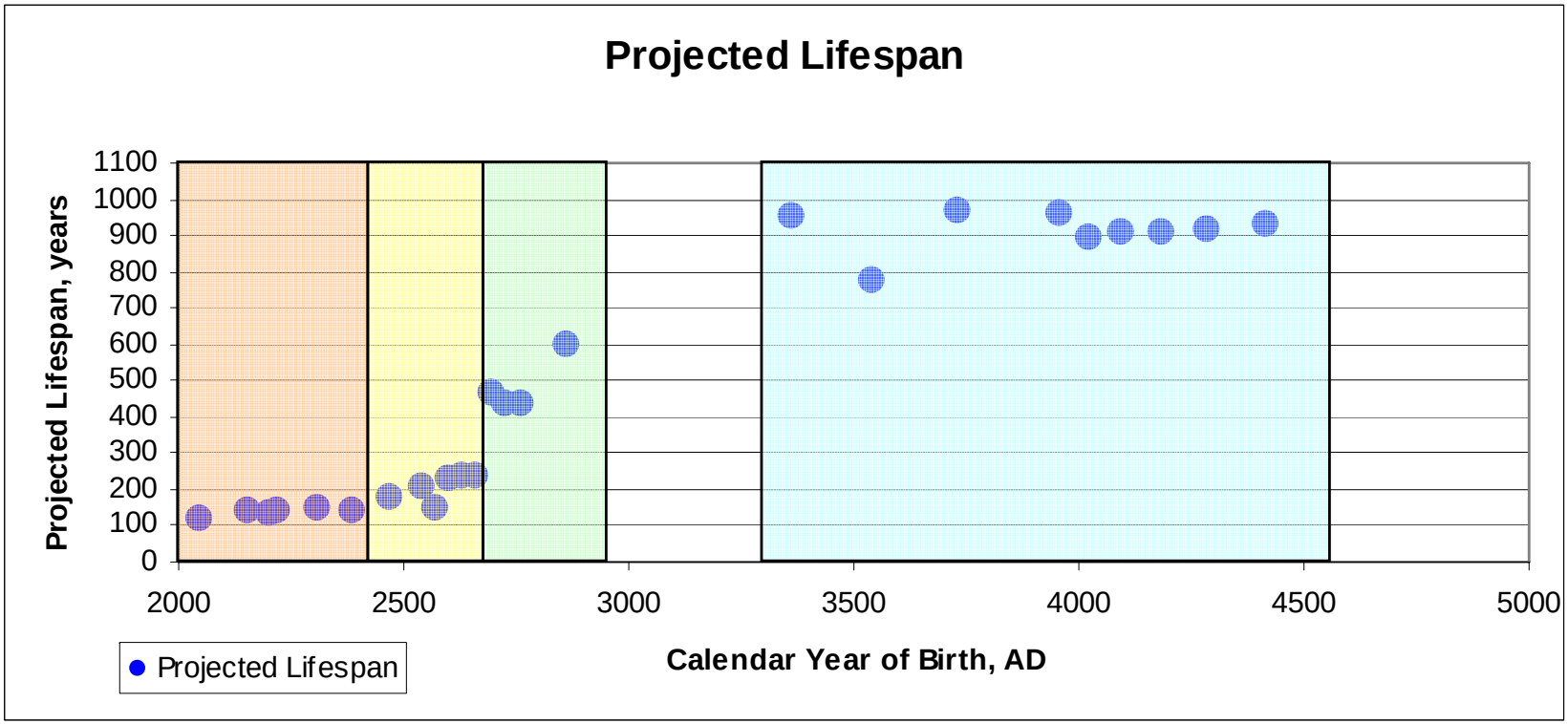
- Perhaps a contribution of a third?
- Okinawans have distinct genetic advantages
- HLA (human leukocyte antigen) genetic polymorphisms
- Possible fibrinogen-related gene polymorphisms leading to lower rates of heart disease

Fountain of Youth

“A frail old man could become so completely restored that he could resume "all manly exercises… take a new wife and beget more children” - Herrera:

- Genetic Engineering
- Nanotechnology

Where could we go from here ?



Conclusions

- Evolutionary mechanisms may prevent the attainment of truly old age for most
- We can limit the costs of long term care to society if morbidity in old age is compressed
- Leading healthier lifestyles will help
- No magic bullet for the foreseeable future
- Methuselah may / may not have needed LTC (but it was cheaper in his time)