Mortality postponement, mortality compression and successful retirement

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Quick summary

Analyzes historical changes in period old-age mortality in industrialized countries the context of the Gompertz Law. Find that:

1. The Gompertz Law has become an increasingly poor fit due to shifting of some deaths from the the seventh and eighth to the eighth and ninth decades of life;
2. Improvements in longevity have been due to a mix of compression, postponement and growing Gompertzian error (largely compression); and
3. Improved old-age longevity has indeed increased retirement savings targets, the presence of significant mortality compression has also reduced the risk caused by uncertainty in the length of life in both absolute and relative terms

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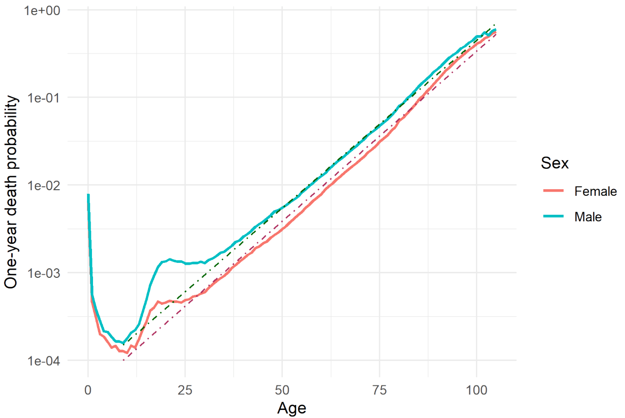
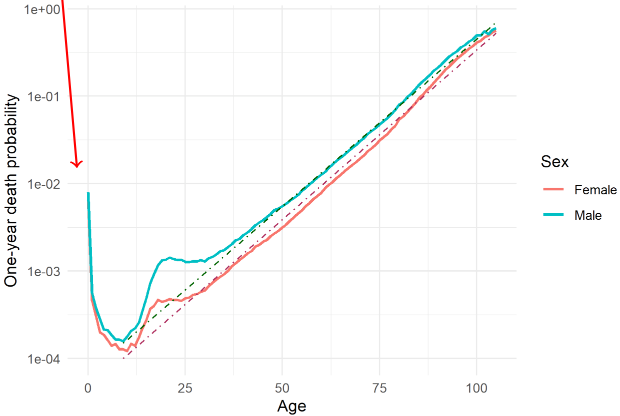
Basics of human mortality (US: 2000)



Basics of human mortality (US: 2000)

High birth and infant mortality



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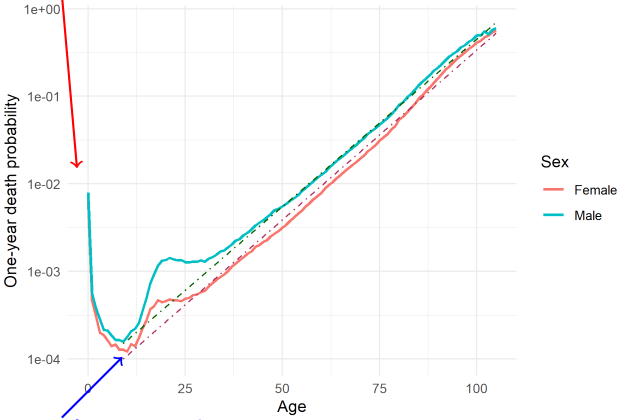

Lifetime low mortality around age 9

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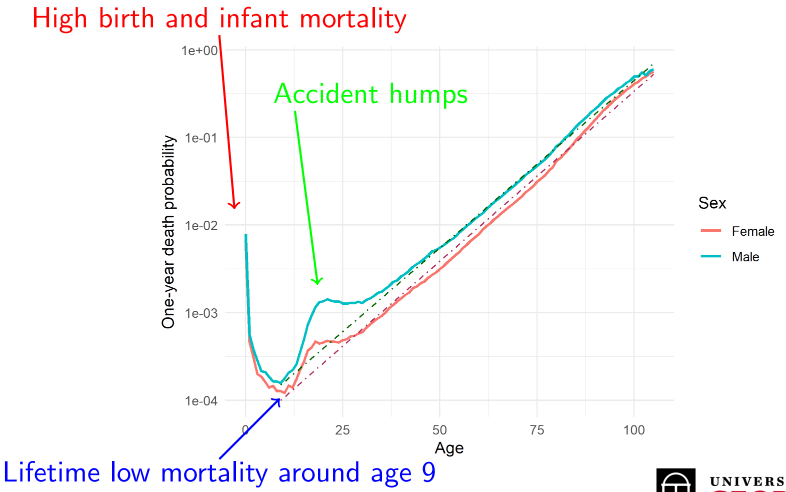

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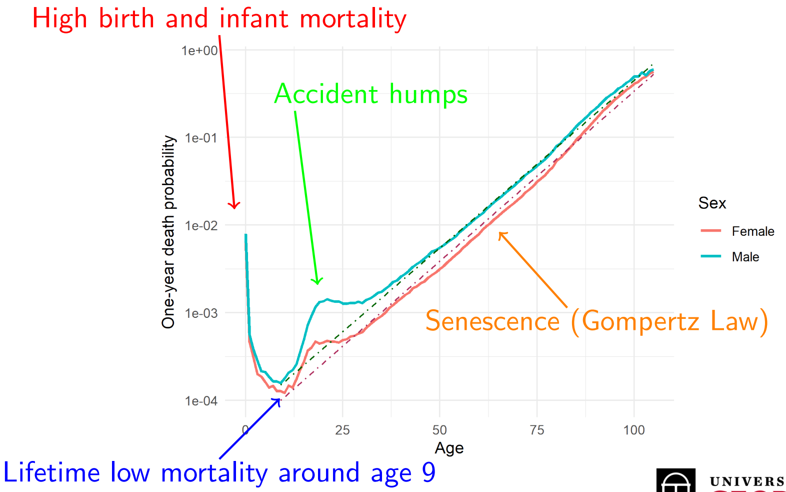
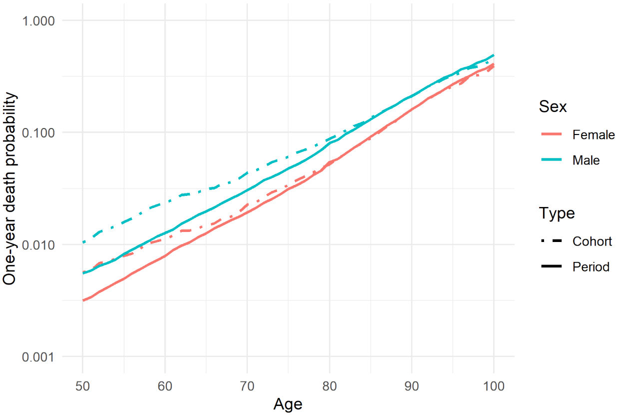


Period vs cohort (US: 2000 / Gen. of 1910)



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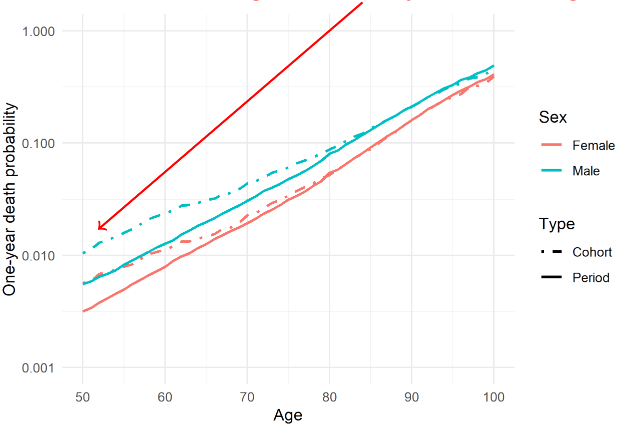
Period vs cohort (US: 2000 / Gen. of 1910)

Gen. of 1910 had higher mortality at 50 than gen. of 1950



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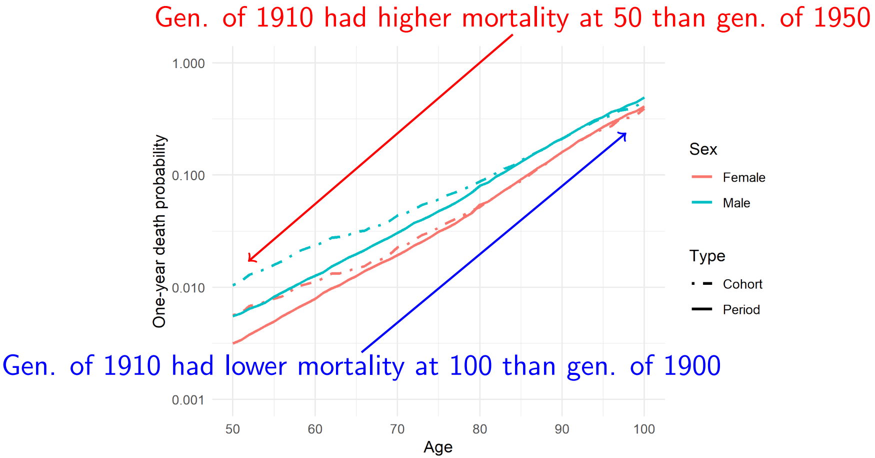
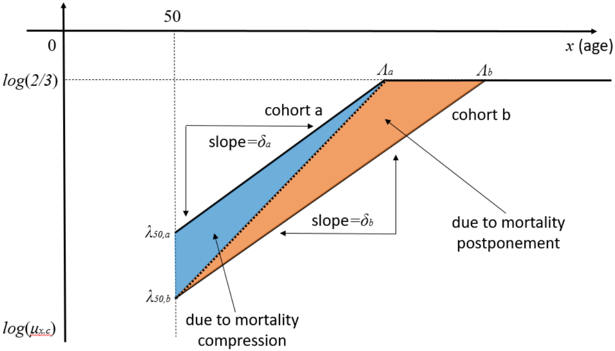


Gompertz Law

$$log(m_x) = \lambda + \delta(x - 50) + \epsilon_x \quad (1)$$

1. Captures broad features of shape of mortality curve above age (say) 50
2. Fails at very high ages due to differential frailty within each cohort and resulting survivor bias
3. Define the Gompertzian Maximum Age (GMA, denoted Λ) as that age where the Gompertz Law would predict that mortality intensity first reaches 2/3 (so annual probability of death ~ 0.5); (contested) evidence that mortality plateaus at this rate.

Using the Gompertz Law to divide changes in mortality between compression and postponement



Plan of action

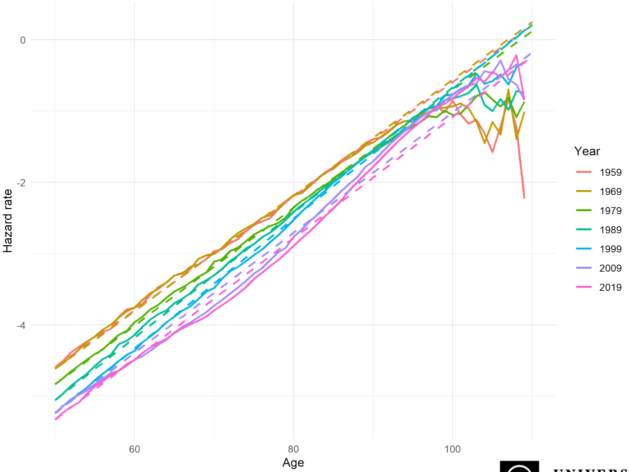
1. Fit the Gompertz law to mortality rates over age 50 to period population mortality rates from the Human Mortality Database over roughly the period 1960-2020 (subtract one year due to Covid)
2. Calculate measures of interest (mean, percentiles of actual and fitted age-at-death distribution; GMA)
3. Disaggregate changes in measures of interest to changes due to compression, postponement and Gompertzian error (not merely academic pedantry, as we will see!)

Fit the Gompertz Law to mortality rates over 50

Technical details in appendix

Panel A: US Males aged 50	1959	1969	1979	1989	1999	2009	2019	Total Δ
Intercept (A)	-4.5963	-4.6171	-4.8345	-5.0566	-5.2421	-5.2342	-5.3302	
Slope (B)	0.0801	0.0811	0.0826	0.0878	0.0911	0.0843	0.0849	
GMA (C)	102.35	101.92	103.59	102.99	103.09	107.3	107.98	5.63
Var(GMA) (D)	0.1743	0.1918	0.1415	0.1083	0.1135	0.4266	0.4173	
Exp. age at death (Gomp) (E)	72.9	72.92	74.75	75.94	77.06	78.39	79.2	6.30
Panel B: US Females aged 50	1959	1969	1979	1989	1999	2009	2019	Total Δ
Intercept (A)	-5.2074	-5.2505	-5.4632	-5.6282	-5.7897	-5.7217	-5.8165	
Slope (B)	0.0893	0.088	0.0876	0.0919	0.0972	0.0912	0.0923	
GMA (C)	103.78	105.03	107.72	106.85	105.41	108.32	108.62	4.84
Var(GMA) (D)	0.2391	0.2801	0.2711	0.1752	0.1657	0.4036	0.4424	
Exp. age at death (E)	77.09	77.75	79.93	80.59	80.93	81.66	82.31	5.22

Fitted and actual mortality hazard rates: US males



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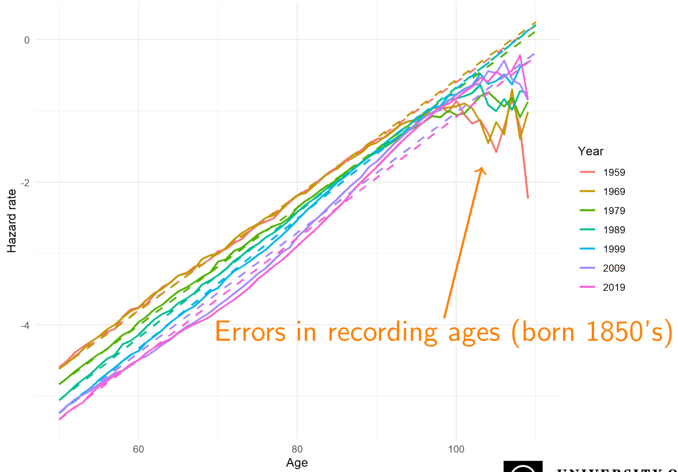

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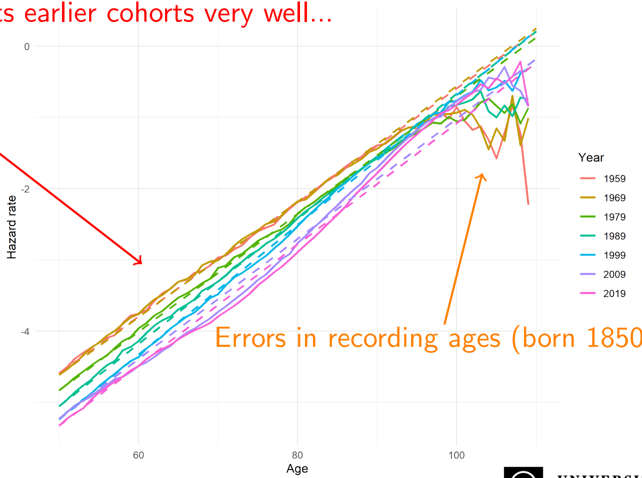
Fitted and actual mortality hazard rates: US males

Gompertz law fits earlier cohorts very well...



Errors in recording ages (born 1850's)

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... but increasingly poor fit over time

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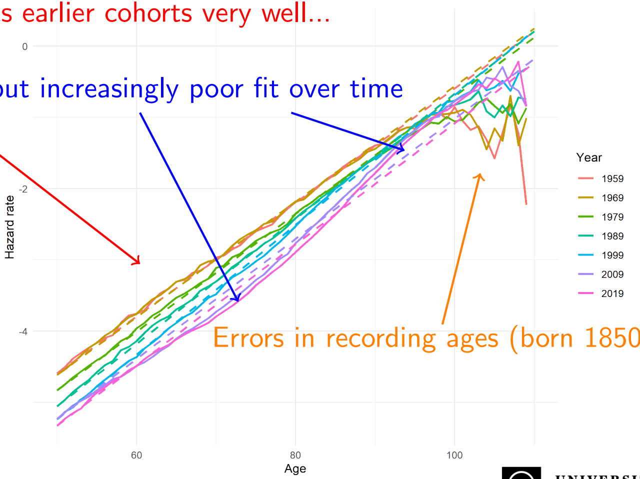
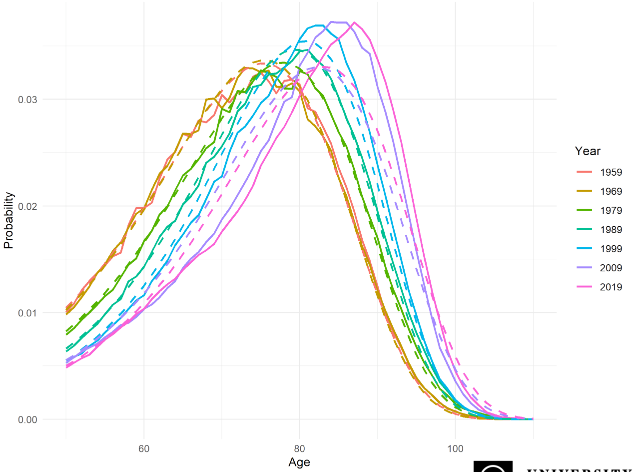


Theoretical dstbn of age-at-death: US Males



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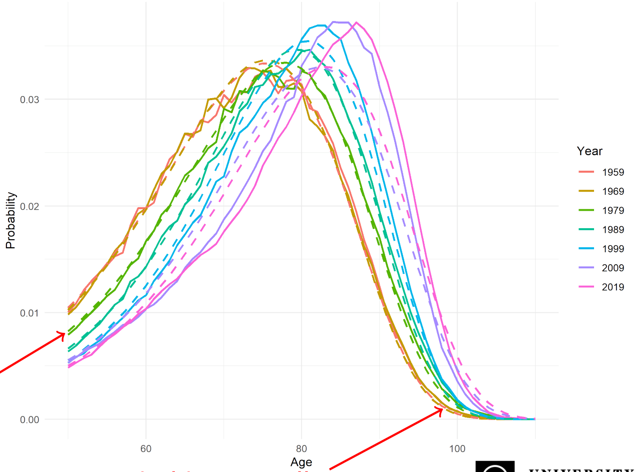
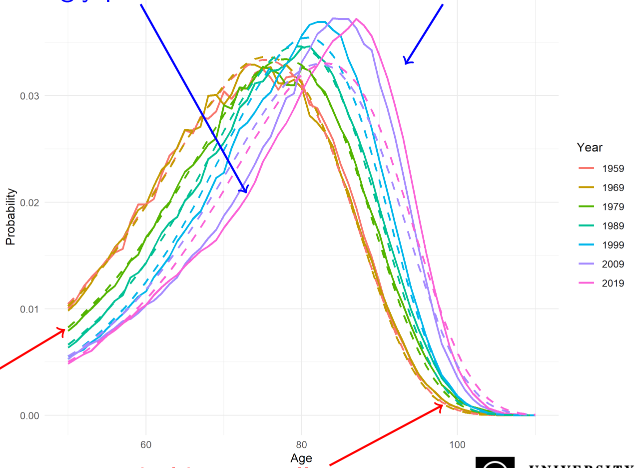


Gompertz law fits young and old ages well...

Theoretical dstbn of age-at-death: US Males

... but increasingly poor fit over time in the middle



Gompertz law fits young and old ages well...

Changes in measures of interest

Panel A: US Males aged 50	1959	1969	1979	1989	1999	2009	2019	Total Δ
Expected age at death (G)	73.09	73.01	74.98	76.18	77.6	79.48	80.09	7
Δ due to: postponement (H)	-0.11	0.47	-0.18	0.03	1.37	0.22		1.8
compression (I)	0.13	1.36	1.38	1.09	-0.05	0.6		4.5
model error (J)	-0.1	0.14	0	0.3	0.57	-0.21		0.7
Median age at death (K)	72.53	72.38	74.56	76.08	77.92	80.31	81.02	8.48
Δ due to: postponement (L)	-0.11	0.47	-0.19	0.03	1.39	0.23		1.83
compression (M)	0.16	1.57	1.57	1.22	-0.05	0.67		5.13
model error (N)	-0.2	0.15	0.13	0.59	1.05	-0.19		1.53
75th perc. of age at death (O)	80.47	80.24	82.43	83.54	84.87	87.18	88.08	7.60
Δ due to: postponement (P)	-0.16	0.69	-0.26	0.05	1.92	0.31		2.54
compression (Q)	0.14	1.39	1.36	1.04	-0.04	0.57		4.46
model error (R)	-0.21	0.12	0.01	0.24	0.43	0.02		0.6
90th perc. of age at death (S)	86.37	86.32	88.39	89.19	90	92.04	92.87	6.5
Δ due to: postponement (T)	-0.21	0.86	-0.32	0.06	2.34	0.38		3.1
compression (U)	0.12	1.19	1.15	0.87	-0.04	0.47		3.77
model error (V)	0.03	0.03	-0.03	-0.11	-0.26	-0.03		-0.37
95th perc. of age at death (W)	89.49	89.55	91.59	92.21	92.73	94.58	95.35	5.85
Δ due to: postponement (X)	-0.23	0.95	-0.35	0.06	2.55	0.42		3.39
compression (Y)	0.11	1.07	1.03	0.77	-0.03	0.42		3.37
model error (Z)	0.19	0.01	-0.06	-0.31	-0.68	-0.07		-0.91

Effect on retirement savings targets

Savings target measures the multiple of consumption required at age 67 to meet lifetime consumption at each percentile of the age-at-death distribution without taking investment risk

Panel A: Males	Percentile of age-at-death distribution										
	50	55	60	65	70	75	80	85	90	95	GMA
1959	3.58	4.51	5.39	6.28	7.10	7.92	8.77	9.65	10.65	11.93	16.30
1969	3.48	4.39	5.26	6.13	6.98	7.81	8.69	9.59	10.62	11.96	16.18
1979	4.77	5.64	6.49	7.32	8.09	8.87	9.67	10.52	11.49	12.74	16.66
1989	5.62	6.45	7.23	7.96	8.67	9.39	10.13	10.92	11.81	12.98	16.49
1999	6.62	7.37	8.06	8.72	9.36	9.99	10.65	11.34	12.13	13.17	16.52
2009	7.84	8.54	9.19	9.80	10.40	10.99	11.58	12.21	12.91	13.83	17.65
2019	8.19	8.91	9.58	10.20	10.79	11.36	11.94	12.54	13.22	14.09	17.82
Panel B: Females	Percentile of age-at-death distribution										
	50	55	60	65	70	75	80	85	90	95	GMA
1959	6.73	7.42	8.11	8.76	9.38	10.00	10.65	11.35	12.14	13.23	16.71
1969	7.21	7.91	8.58	9.20	9.81	10.41	11.04	11.71	12.49	13.52	17.05
1979	8.41	9.07	9.68	10.27	10.84	11.44	12.03	12.68	13.41	14.36	17.76
1989	8.65	9.30	9.92	10.52	11.09	11.65	12.22	12.84	13.54	14.45	17.53
1999	8.85	9.48	10.07	10.62	11.16	11.69	12.24	12.82	13.49	14.35	17.15
2009	9.63	10.21	10.75	11.27	11.77	12.28	12.79	13.33	13.95	14.78	17.91
2019	9.98	10.55	11.07	11.56	12.03	12.51	13.00	13.52	14.12	14.91	17.98

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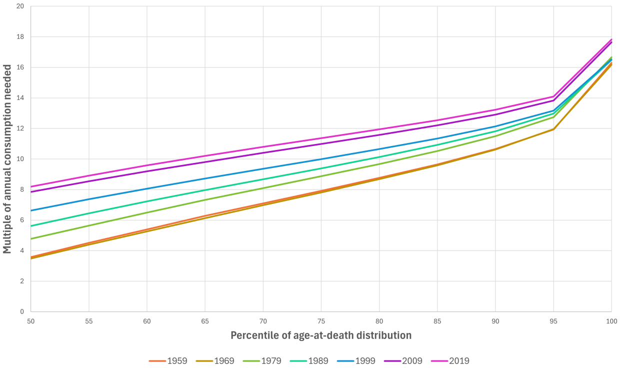
Savings target, US males retiring at 67 (multiple of annual consumption)



Conclusion

- Mortality improvements at older ages are the result of both compression and postponement, with a primary role played by compression (changes in the intercept rather than the GMA)
- Increasing deviations from Gompertz law largely represent compression
- Result: median age-at-death increases faster than higher percentiles and GMA
- (Result: height of modal age-at-death distribution increases)
- Retirement savings targets have increased but the amount of risk has decreased in both absolute and relative terms (good news)
- Caveat: real people age with time; need to examine cohort mortality too! So future mortality changes important