

Economics from the Top Down

new ideas in economics and the social sciences

The Human Lifespan Probably has an Upper Limit ... and Why That's Good

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*We are at war with death and its causes.
We are building towards an infinite horizon.*

— [Bryan Johnson](#)

A common theme in science fiction is that people of the future will live far longer than folks today. The reasoning goes something like this. Historically, human life expectancy was short — often under 30 years. But today, in some wealthy countries, life expectancy is pushing into the upper 80s. Given this trend, it seems possible that the human lifespan could continue to grow forever.

Unfortunately, this thinking is probably wrong. While plausible on the surface, it misunderstands the nature of how the human lifespan has been extended.

The backstory is that for most of human history, about [half of all children](#) died before age 15. For tens of thousands of years, humans made essentially no progress at civilizing this gauntlet of youth. But today, things are different. With the help of modern science, the vast majority of children now reach adulthood. As a consequence, life expectancy at birth has exploded.

What has hardly budged, though, is life expectancy at the *century* mark. Or put another way, while humans have made great strides at allowing the young to survive, we've made virtually no progress at halting the march of old age. True, we can *imagine* a future in which we slow aging; but today, there's

no sign of such an elixir. And so we are faced with a simple mathematical problem; as long as aging remains inexorable, there is likely a natural upper limit to the human lifespan.

And that's probably a good thing. You see, if the elixir of life were actually discovered, the risk is that the spoils of longevity would be hoarded by the rich. Thankfully, the opposite is true today. Indeed, one of the most stunning features of longer life expectancy is that it makes the human lifespan more equal.

Life expectancy explodes

To dive into the science of life expectancy, let's review some recent history. For humans, the last two centuries have been the anthropic equivalent of the [Cambrian explosion](#). For thousands of years prior, the pace of human social evolution was glacial. Then, with the onset of the industrial revolution, virtually every aspect of the human experience changed, including how long we live.

For some context, at the turn of the 19th century, global life expectancy at birth was under 30 years. Today, it is well over 70 years. [Figure 1](#) shows this life-expectancy explosion, which came mostly in the last century.

Looking at this remarkable extension of the human lifespan, we naturally wonder what lies ahead. One possibility is that the pattern over the last century continues indefinitely. That's easy enough to extrapolate. On average, each new year of the 20th century brought a quarter-year extension to global life expectancy at birth. If this ascent continues, global life expectancy will reach 91 years by 2100. And by the mid 24th century (when the events in *Star Trek: The Next Generation* supposedly take place), global life expectancy will surpass 150 years. No doubt many folks (including me) would like to live in this sci-fi future. Sadly, it's almost certainly a fantasy.

For one thing, the continued march of longer living depends in large part on continuous scientific progress, which is not guaranteed. I mean, just look at what the Trump regime is doing today. Forget *new* science ... Trump is busy demolishing *basic* public health policies. If this demolition doesn't stop, Americans are almost surely going to see their life expectancy continue (yes, continue) to drop.¹

¹American life expectancy [peaked in 2014](#) and then plateaued for several years before plunging during the pandemic. It has not since recovered to pre-pandemic levels.

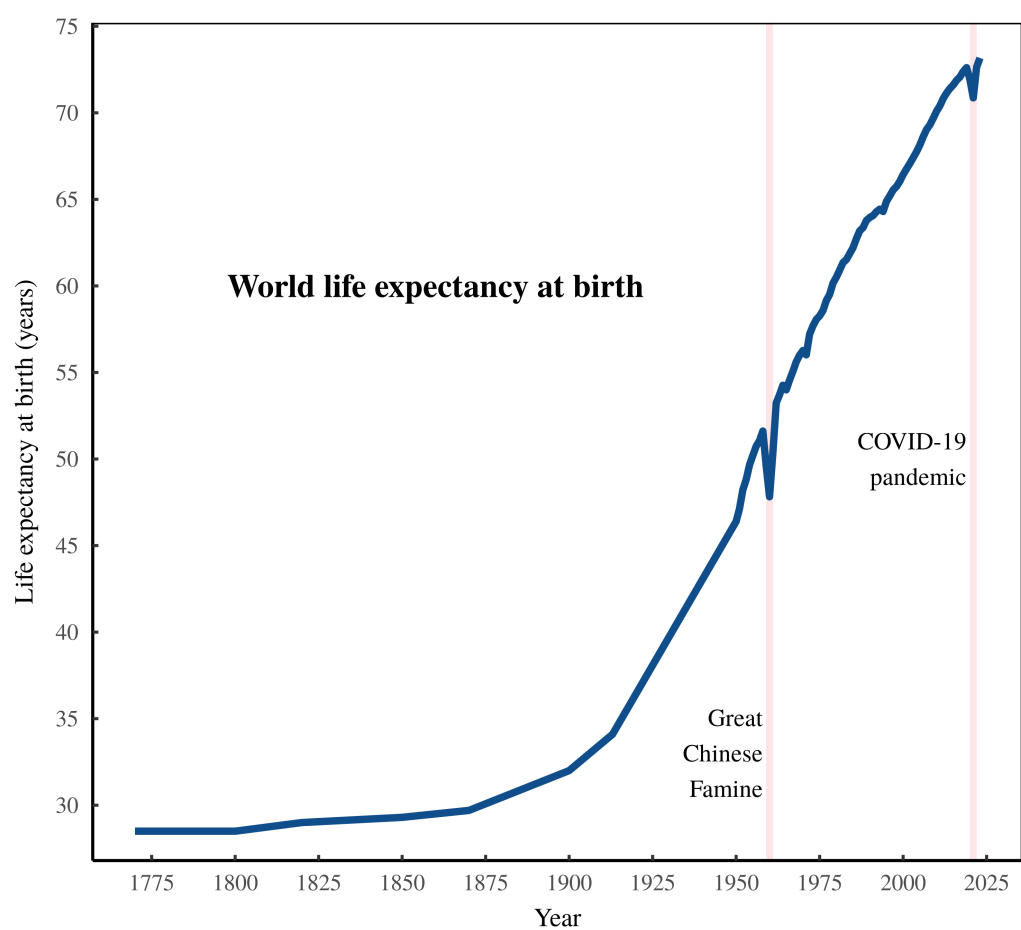


Figure 1: The march towards longer living

The extension of human life expectancy began in earnest in the 19th century, but accelerated during the 20th century. Today, world life expectancy at birth is more than forty years greater than it was in 1800. Note that in this chart, annual data begins in 1950, so we don’t see the impact of the two world wars. But we do see the global impact of the Great Chinese Famine (induced by Mao’s ‘Great Leap Forward’), as well as the more recent carnage caused by the COVID-19 pandemic. [Sources and methods](#)

Let’s suppose, however, that this stupidity is a brief hiccup, and that scientific progress continues for centuries come. Even then, it’s unlikely that life expectancy will rise indefinitely. Perhaps the easiest way to see the problem is to look at trends in life expectancy not at the beginning of life, but near its *end*, where the picture is less sanguine.

Figure 2 illustrates this end-of-life story. Here, I’ve plotted global life expectancy for individuals at age 100. What’s notable is the *lack* of progress. In 1950, centenarians could expect to live for another 1.1 years, on average. By 2023, this life expectancy had been extended by just 0.4 years. In other

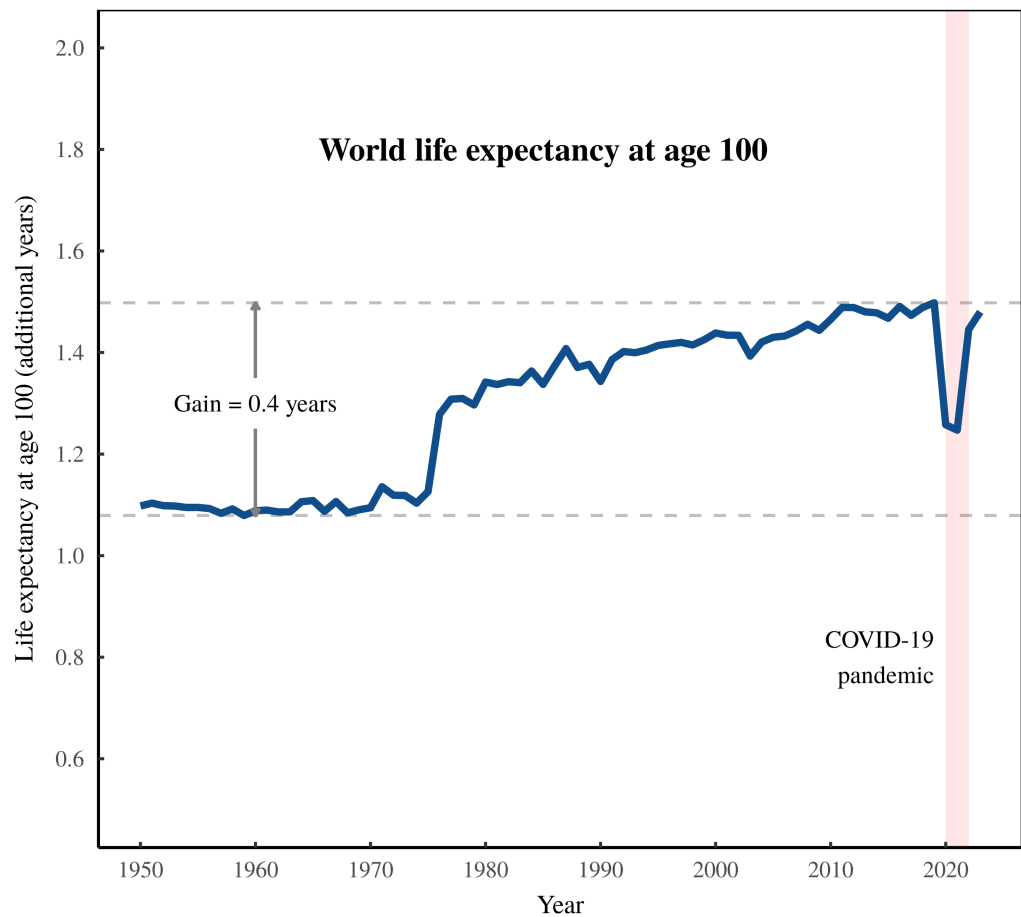


Figure 2: Meager gains — world life expectancy at age 100

Unlike life expectancy at birth, which rose steeply throughout the 20th century, world life expectancy at age 100 remained almost unchanged, rising by just 0.4 years from 1950 to 2023. The caveat is that centenarian life expectancy is difficult to estimate, largely because centenarians are rare. So the data here should be treated with appropriate uncertainty (especially the odd life-expectancy jump during the mid 1970s, which smells of a change in methodology). At any rate, what seems uncontroversial is that today, centenarians don't live much longer than they did in 1950. [Sources and methods](#)

words, despite the massive 20th-century gains in the average human lifespan at birth, longevity amongst the extremely old hardly budged. It's this failure to extend the lifespan of the very old which suggests an upper limit to human life expectancy.

A tale of two gauntlets

To understand the historical route to longer life expectancy, it's helpful to think of the human lifespan as having two survival gauntlets — a gauntlet of youth and a gauntlet of old age.

The gauntlet of youth begins at birth, which is one of the most dangerous periods of life. Historically, many individuals died during infancy, and only about half of children reached adulthood. In other words, the gauntlet of youth was brutal. Fortunately, things have changed. In fact, reducing infant mortality is *the* most important factor in increasing human life expectancy.

Figure 3 illustrates. Here, the horizontal axis shows life expectancy at birth, measured for every country since 1950. The vertical axis shows the rate of infant mortality (the portion of infants that die before age one). What we find is that rising life expectancy comes with a massive decline in infant mortality. For example, when life expectancy is below 30 years, about 20% of infants die before age one. But when life expectancy is over 80 years, infant mortality is more than 100 times lower.

The secret to cutting infant mortality turns out to be quite simple, largely because the bodies of the young are designed to survive. Basic sanitation, basic infection control, and basic medical interventions at birth go a long way towards keeping newborns alive.² And if children survive infancy, there's a good chance they'll reach adulthood.

When we turn to the gauntlet of old age, though, the same principles do not hold. Yes, modern medicine can treat some of the downstream effects of old age (like cancer, heart disease, and diabetes). But as far as halting

²Until recently, cities were demographic sinkholes where death rates exceeded birthrates. Given the lack of sewers, and the tendency for water wells to get laced with cholera, it's not hard to see why. Today, we associate long living with fairly advanced forms of healthcare. But early on, the gains came from simple things like sewage systems and water treatment. (Vaccines and antibiotics also made a huge difference.)

It's also worth noting that once the perils of contaminated water were discovered (by [John Snow](#) in 1855), it took major prodding to get governments to actually do something about the problem. For example, see George Pinwell's 1866 cartoon [Death's Dispensary](#).

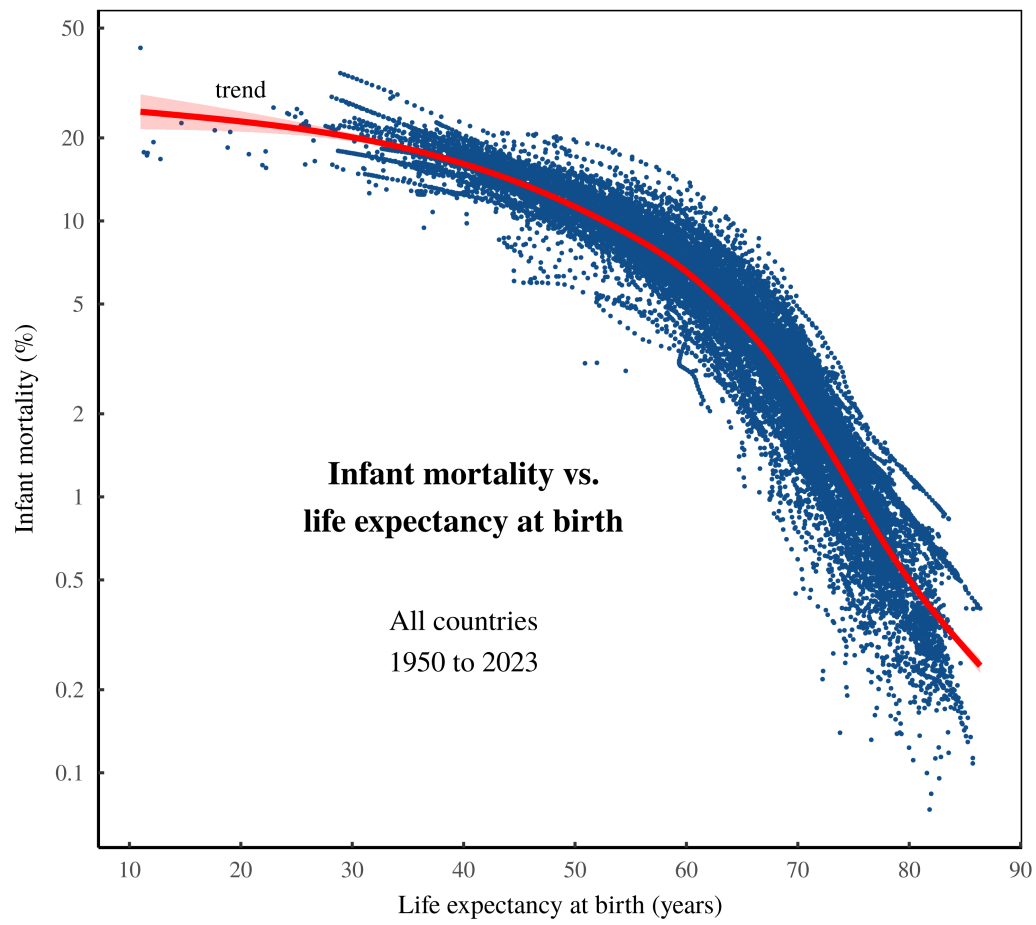


Figure 3: The collapse of infant mortality

Reducing infant mortality is *the* most important factor in increasing life expectancy at birth. Here, each point represents a country, observed between 1950 and 2023. The vertical axis shows the infant mortality rate — the portion of infants that die before age one. (Note the log scale.) The horizontal axis shows life expectancy at birth. [Sources and methods](#)

aging itself, science has proved impotent. And that’s not surprising. Aging likely has deep evolutionary roots in metabolism itself ... roots which are not easily upended.³

In short, unlike the bodies of infants, which are designed to live, the bodies of the extremely old are riddle with the insults of age. Which is why it’s unsurprising that old-age mortality rates remain intransigent.

³Regarding the metabolic roots of aging, see Nick Lane’s recent book [Transformer: The Deep Chemistry of Life and Death](#). Lane argues that the torrent of cellular metabolism inevitably creates damage, which accumulates with time. In this light, aging is not a design feature, so much as a evolutionary side effect which natural selection can tweak but not remove.

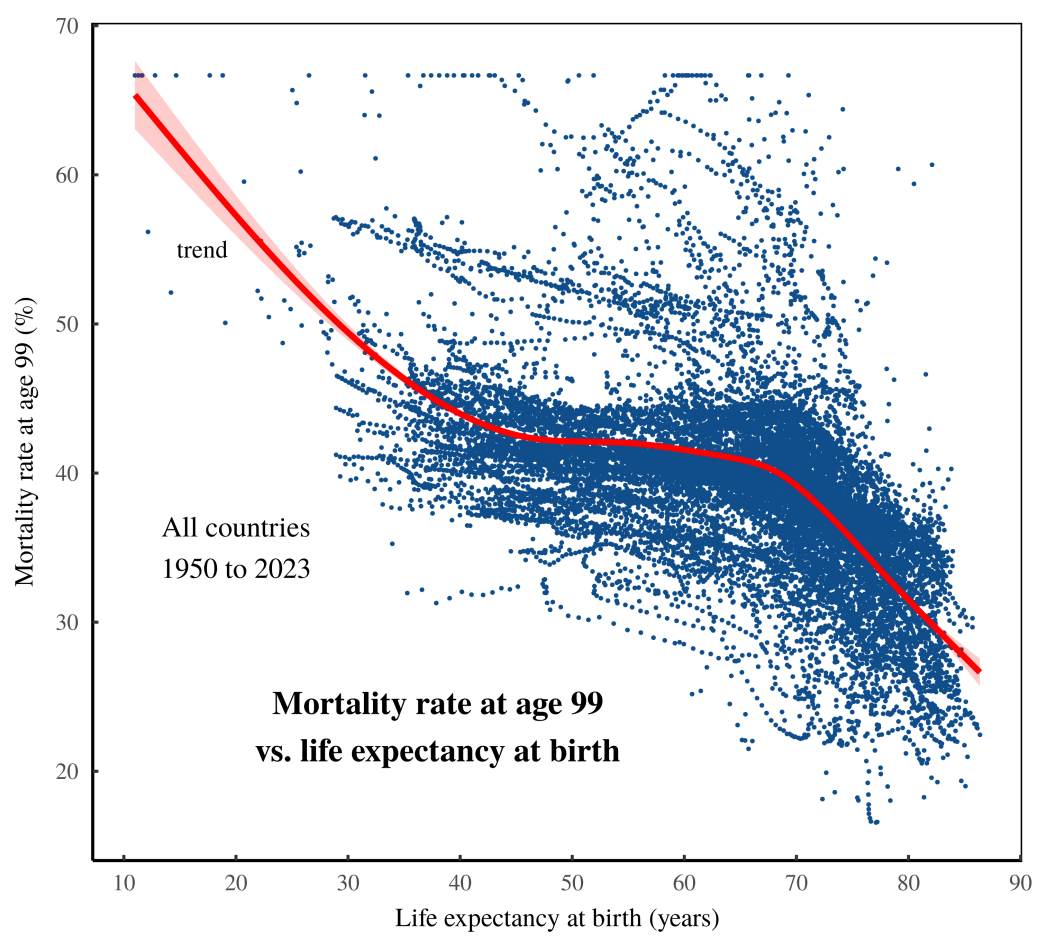


Figure 4: Stubbornly high mortality rates at age 99

Unlike infant mortality, which plummets with rising life expectancy (see Figure 3), mortality rates at age 99 don’t move much. Here’s the modest pattern across all countries between 1950 to 2023. On average, a five decade increase in life expectancy at birth comes with a halving of mortality at age 99. [Sources and methods](#)

Figure 4 illustrates the lack of progress. Here, I’ve plotted mortality rates at age 99 as a function of population life expectancy at birth. Across more than seven decades of rising life expectancy, mortality rates at age 99 are barely halved. So yes, there has been humble progress at taming the gauntlet of old age ... but it is nothing like the success at civilizing the gauntlet of youth.

The mathematics of aging

To understand the limits of the human lifespan, it’s helpful to explore the mathematics of aging — by which I mean the statistics associated with getting older. Sadly, age makes almost everything worse.

Professional athletes are a conspicuous example. Athletes typically reach their prime in their mid 20s, after which their performance gradually declines. (This pattern is known as the [aging curve](#).) By age 40, most athletes have retired.⁴

Elsewhere, the insults of aging are less visible, but still detectable. Of course, the most insulting effect of aging is death itself. From adulthood onward, the risk of death increases inexorably with age. Figure 5 illustrates the pattern in the United States.

Here, the blue curves shows how mortality rates change with age. Note the J-shaped pattern, which appears when we plot mortality rates on a logarithmic scale. At birth, mortality rates are quite high, but drop quickly for the individuals who survive infancy. By age 10, mortality rates reach a lifetime low. From then on, things get worse. During the teen years, mortality rates rise, largely because teens take bigger risks than children.⁵ And from adulthood onward, mortality rates climb inexorably. This ascent marks the statistical march of senescence.

Shifting the mortality-rate spectrum

I highlight these age-specific mortality patterns because they are key to understanding the human lifespan. At the most basic level, life expectancy *rises* because mortality rates *fall*.

Figure 6 shows this tendency, measured across all countries between 1950 and 2023. Here, I've plotted age-specific mortality rates as a function of population life expectancy (shown in color). Let's run through the evidence.

First, note that regardless of life expectancy, all the mortality-rate curves have a 'J' shape. Across every population, the risk of death is high at birth, low during early adolescence, and then rises inexorably during adulthood. Second, note that higher life expectancy comes with lower mortality rates at every age. This connection is a logical necessity; to live longer, people must

⁴Since my topic here is life expectancy, it's worth noting that there's a connection between the rate of athletic performance decline and overall life expectancy. A [2023 study](#) by Saul Newman found that among professional baseball players, a rapid age-related decline in performance is associated with a shorter lifespan.

⁵In the US, the leading causes of [teen death](#) are, in descending order, unintentional injuries (mostly car crashes and drug overdoses), homicide, and suicide.

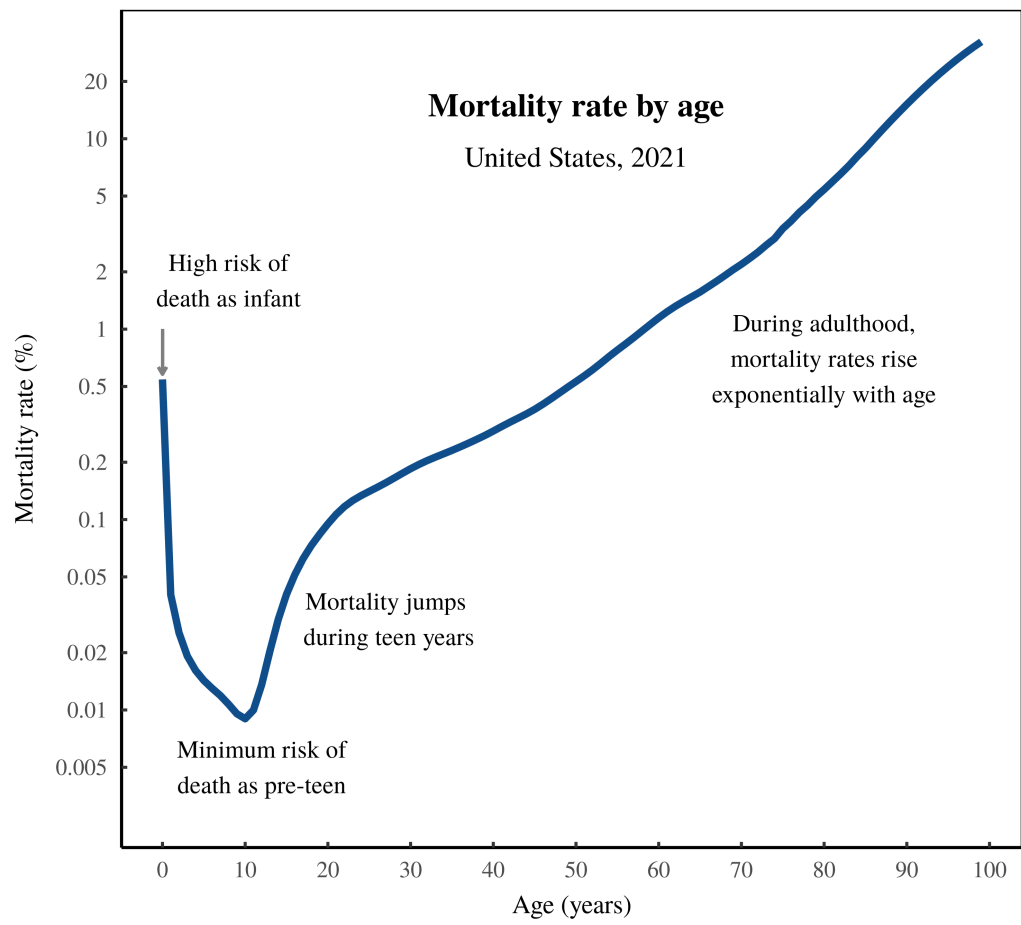


Figure 5: Mortality rates by age in the United States

When plotted on a logarithmic scale, age-specific mortality rates have a characteristic J shape. Mortality is high at birth and then shrinks during early childhood. It spikes again during teen years, after which it rises perpetually with adult age. [Sources and methods](#)

die less. Third, and most importantly, note that mortality-rate reductions are *not* even across ages; instead, the reductions are large during youth and small during old age.

It is this last fact that is crucial for understanding the limits of the human lifespan. If greater life expectancy was achieved by taming both the gauntlet of youth *and* the gauntlet of old age, there would be hope for an unbounded lifespan. However, all of the evidence points to the opposite scenario. While we have succeeded at reducing mortality among the young, mortality among the old remains stubbornly high.

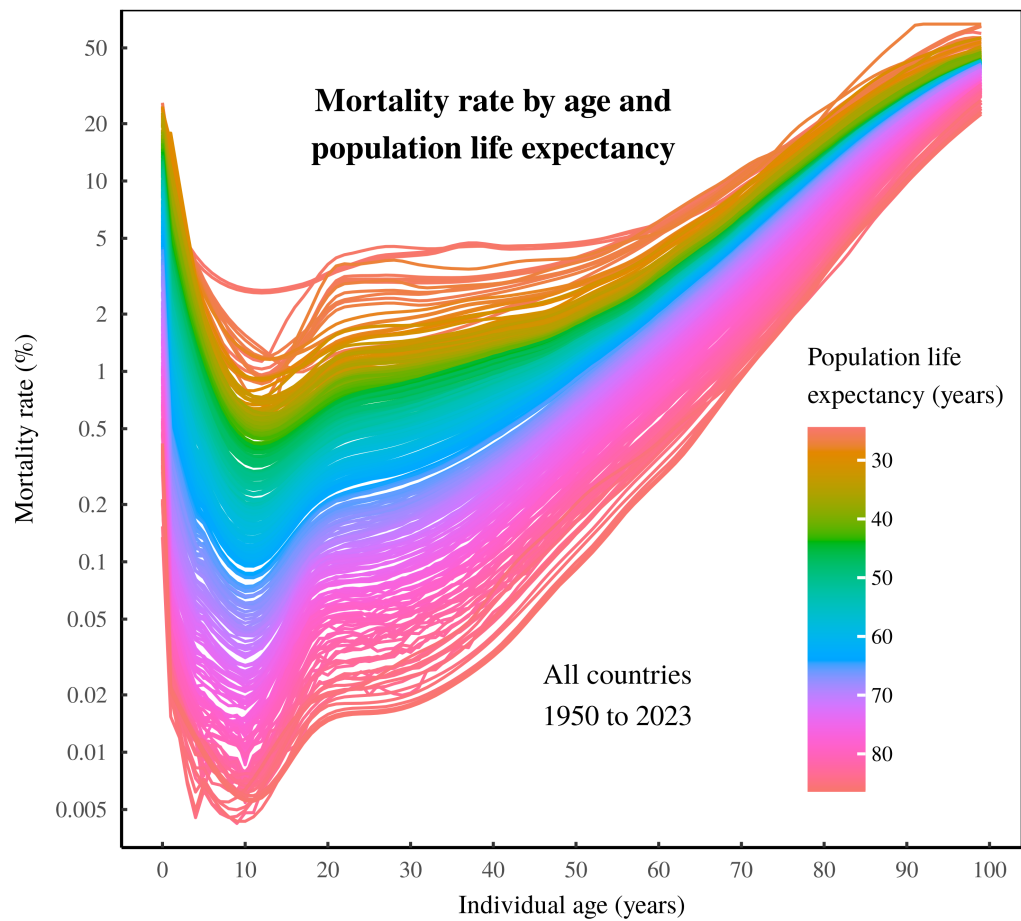


Figure 6: Living longer by dying less — the spectrum of age-specific mortality rates

Each colored curve shows mortality rates as a function of age, measured for populations with a specific life expectancy (indicated by color). As life expectancy rises, mortality rates fall. However, the reduction is most pronounced among youth, and least pronounced among the elderly. Note: to create the mortality curves, I have binned country-year observations by life expectancy, and then averaged the age-specific mortality rates within each bin. [Sources and methods](#)

Figure 7 visualizes this intransigent pattern, which I’ve dubbed the ‘funnel of death’. What I’ve done here is plot age-specific mortality rates *relative* to the baseline for a population with a life expectancy of 35 years. (This mortality-rate baseline corresponds to the dashed horizontal line.) The colored lines illustrate how mortality rates shift (downward) as population life expectancy increases.

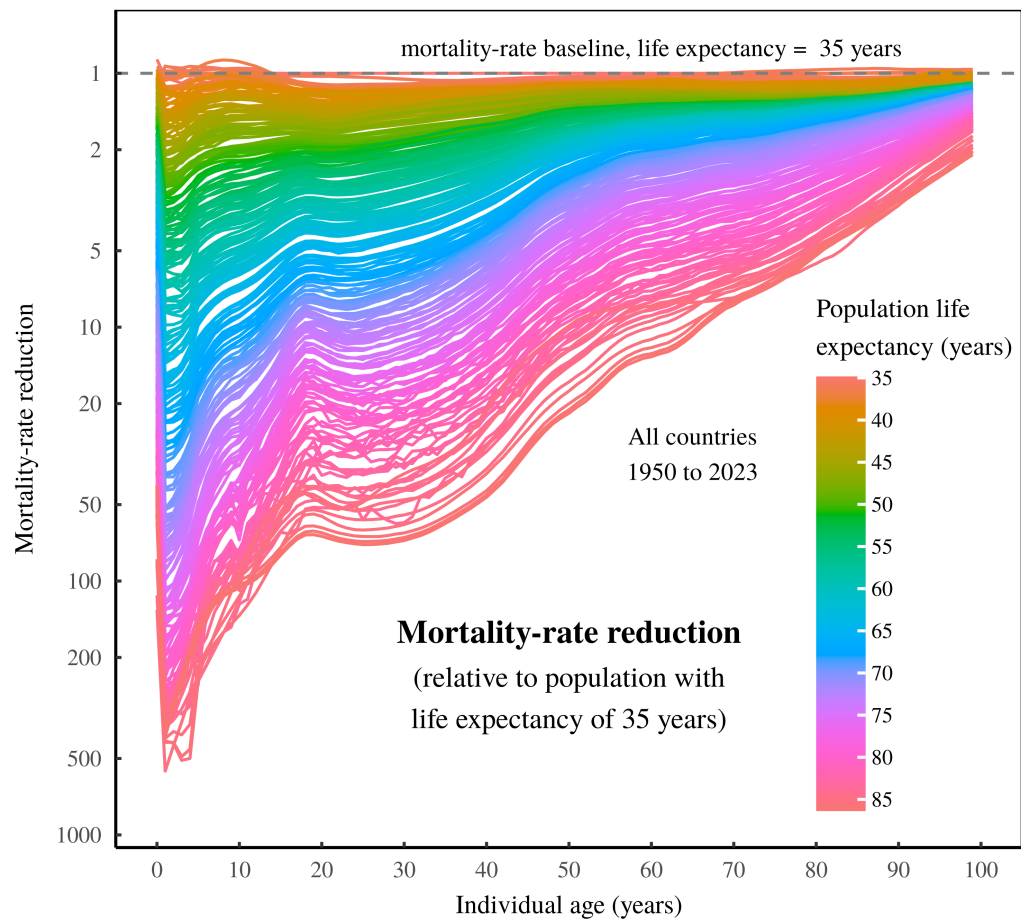


Figure 7: The funnel of death

Each colored curve plots the reduction in age-specific mortality rates, measured relative to a population with a life expectancy of 35 years. Longer life expectancy comes with a huge reduction in infant mortality. But for the remainder of life, these gains are winnowed away, until the elderly are funnelled towards certain death, regardless of population life expectancy. Note: to create the mortality curves, I have binned country-year observations by life expectancy, and then averaged the age-specific mortality rates within each bin. [Sources and methods](#)

The resulting triangular shape highlights the lopsided nature of mortality-rate reductions. The most spectacular mortality-rate reductions come at birth. But from infancy onward, these gains are gradually winnowed away until we reach age 90 and up. There, regardless of population life expectancy, individuals are funnelled relentlessly towards death.

The upper limits of the human lifespan

Because the gauntlet of old age remains intransigent, it follows that the human lifespan probably has an upper limit. Here are some ways to estimate it.

A popular approach is to assume that the old-age gauntlet narrows perpetually, until it eventually collides with certain death. With this model, we can estimate the maximum possible lifespan of a human *individual*.

Figure 8 illustrates this method using US data in 2021. Here, the blue curve shows how US mortality rates rise as a function of age. To model this march of senescence, we fit the mortality-rate data with an exponential function (shown in red). Then we extrapolate this function until it crashes into the mortality rate of 100%. At this point, death becomes certain, which means we have estimated the maximum lifespan of an individual in the given population. For the US in 2021, this maximum lifespan is about 113 years.

While this exponential method is conveniently simple, it's also quite unrealistic. In my mind, there is no compelling reason to suppose that the human body has an insurmountable maximum lifespan. Yes, death may become more probable with older age ... but imminent death is never certain. Which is to say that we need a more plausible way to model mortality rates during extreme old age.

A better approach is to treat the gauntlet of old age as something that narrows perpetually, but never actually 'touches' certain death. A simple way to model this narrowing is with a logistic function. Figure 9 illustrates the revised method.

As before, we fit our model to empirical mortality rates during late adulthood. Then we use the model to extrapolate the pattern into extreme old age. The difference is that with our logistic model, mortality rates bend towards certain death, but never actually touch it. As a consequence, this model presumes that there is no maximum human age; continued survival is always a matter of (increasingly minute) probability.

While this logistic model doesn't define a maximum lifespan, it does provide a way to define the *onset* of the old-age gauntlet — an onset that sets an effective upper bound on human life expectancy.

Here's how it works.

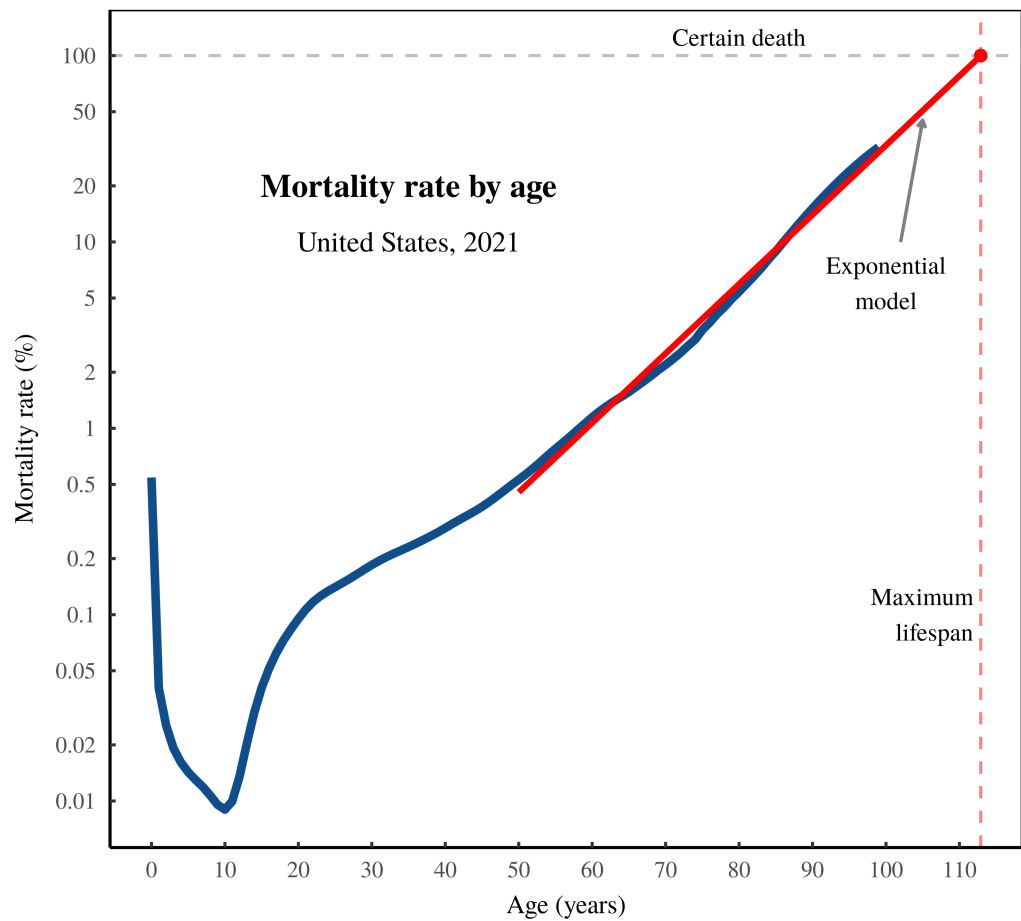


Figure 8: Crashing into certain death — the exponential model of the old-age gauntlet

This chart illustrates one method for estimating the maximum human lifespan. Given empirical data for age-specific mortality rates (here, I’ve used US data, shown in blue), we fit the late-adulthood data with an exponential function (red). Then, we extrapolate the trend until it crashes into certain death — the point where mortality is 100%. The age at which this collision occurs is an estimate for the maximum lifespan for individuals within the population. For the US in 2021, this collision happens at age 113. [Sources and methods](#)

I’ll define the ‘old-age gauntlet’ as the point when death becomes more probable than survival. This threshold occurs when age-specific mortality rates exceed 50%. In Figure 9, I’ve marked the gauntlet zone with the red shaded region. Now, in the United States, the empirical data never enters this region. But supposing that our logistic model is sound, we can extrapolate the trend, and estimate the age at which mortality rates exceed 50%. In the US in 2021, I find that this old-age gauntlet begins at about age 106.

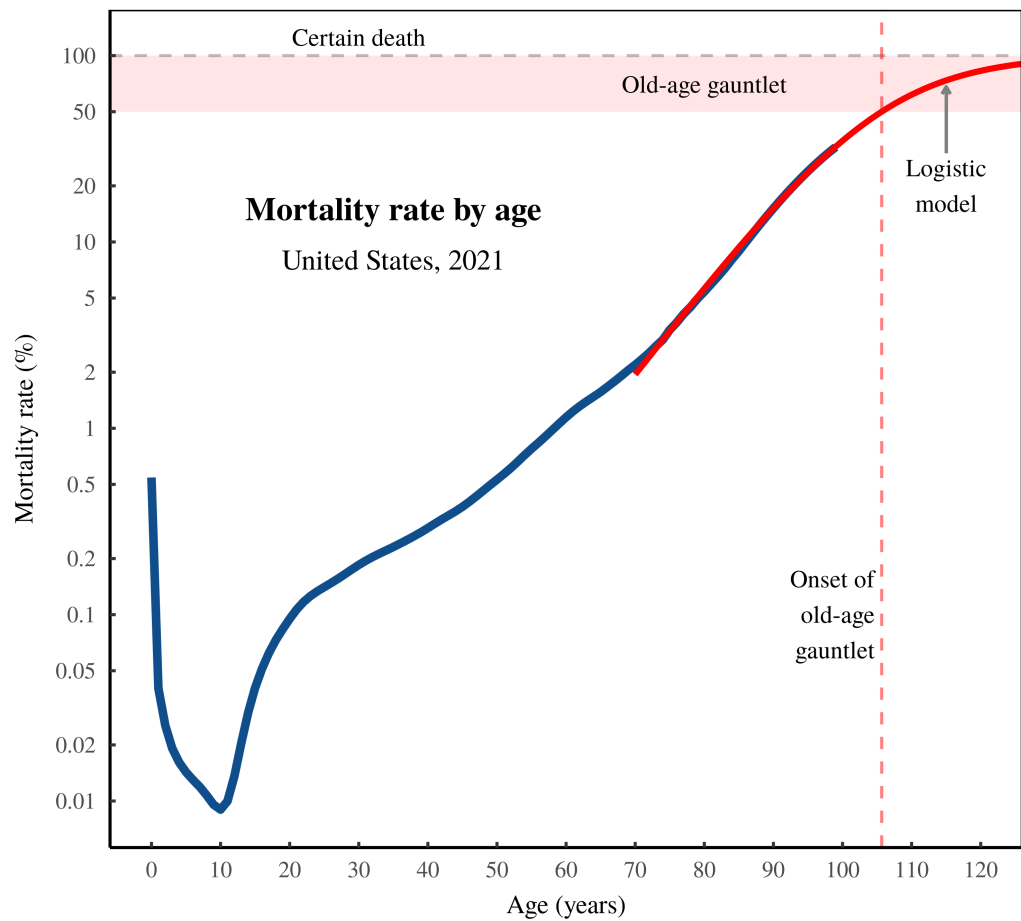


Figure 9: Approaching, but never touching, certain death — the logistic model of the old-age gauntlet

This chart illustrates a second (improved, in my opinion) method for extrapolating mortality rates into extreme old age. Here, I fit late-adulthood mortality rates with a logistic model. When we use this model to extrapolate mortality rates into old age, it bends towards the certain death mark, but never touches it. Consequently, this model does not define a maximum lifespan for individuals. But it does provide a way to measure the onset of the old-age gauntlet, which I define as the age when mortality rates cross the 50% mark. For the US in 2021, this threshold occurs at age 106. [Sources and methods](#)

So what should we make of this onset? Well, because the old-age gauntlet is a statistical concept, it says little about the survival of specific individuals. (In a large population, a small fraction of people will defy the odds and live past age 106.) That said, the onset of the old-age gauntlet is important, because it signals the effective upper limit to human life expectancy in the given population.

The logic works as follows. Once individuals enter the old-age gauntlet, death becomes more probable than survival, which means that their life expectancy is extremely short. (It is measured in months, not years.) Now, imagine a future society in which virtually everyone lives to age 105, yet the old-age gauntlet remains entrenched at age 106. In this scenario, the population life expectancy would remain close to 106, simply because so few people would surpass this age.

Now, we can quibble about whether this scenario is likely. (If most people survive to age 105, then the onset of the old-age gauntlet might get pushed back.) But the point is that the mathematics are clear: the onset of the old-age gauntlet sets the effective upper limit to the average human lifespan.

The old-age gauntlet has a sticky onset

Having defined a way to estimate the onset of the old-age gauntlet, let's see how these estimates vary with population life expectancy at birth. Figure 10 shows my measurements.

As life expectancy rises, the onset of the old-age gauntlet slowly recedes. However, the recession has an intriguing 'Z' shape, with a curious plateau at age 102. Why?

I have some thoughts about where this Z-shaped pattern comes from. But first, let's get to the bad news.

Even if onset of the old-age gauntlet continues to recede as life expectancy pushes into the 90s, the current trend implies a maximum trajectory. The reason is quite simple. By definition, life expectancy at birth cannot (significantly) exceed the onset of the old age gauntlet. But according to current trends, the old-age gauntlet is retreating much slower than life expectancy is rising, which means that the two numbers will eventually collide. If this trend continues, I estimate that the collision will occur at age 117. (See Figure 13 in the appendix for more details.) I consider this age a reasonable estimate for the maximum possible human life expectancy. Time will tell if this prediction is correct.

Back to the Z-shaped trend in Figure 10. What causes it? One possibility is that it's an artifact of the way I've analyzed the data. (I run some consistency checks in the appendix, and don't find any obvious problems.) But for argu-

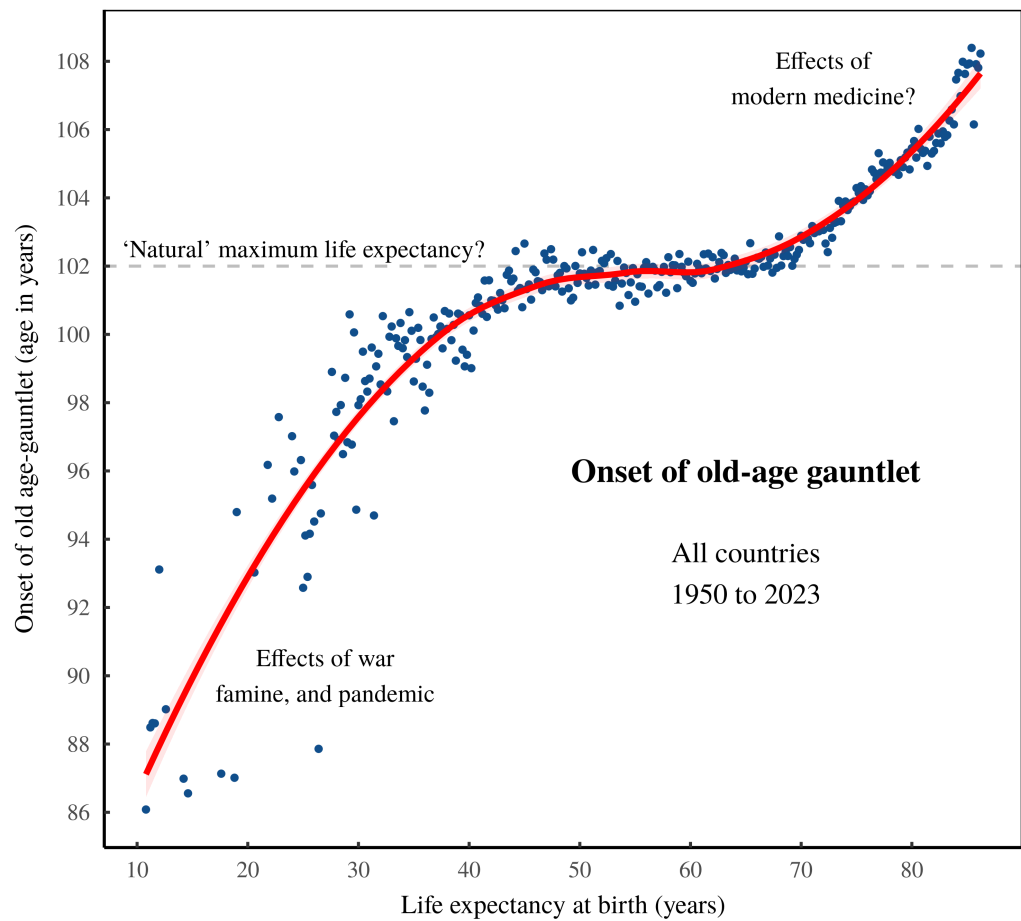


Figure 10: The sticky onset of the old-age gauntlet

This chart shows my measurements for the onset of the old-age gauntlet (the adult age where mortality rates exceed 50%), measured as a function of life expectancy at birth. Note: each point represents a binned estimate, in which I first group mortality-rate observations by population life expectancy, average the age-specific mortality rates, and then fit the resulting data with a logistic function, which I use to infer the onset of the old-age gauntlet. [Sources and methods](#)

ments sake, let’s suppose that the Z-shaped pattern is a real feature of the human experience. If so, an intriguing possibility is that the plateau region illustrates some sort of ‘natural’ maximum for human life expectancy.

Of course, the word ‘natural’ needs some caveats. In many ways, extreme old age is not ‘natural’, in the sense that wild animals rarely reach this stage of senescence. In the wild, there’s too much competition, too many predators, and too many diseases for animals to reach ‘nursing-home’ age. So paradoxically, the ‘natural’ limits of an animal’s lifespan only reveal themselves in the safety of captivity, where individuals are able to die of old age.

By analogy, perhaps we can think of the fruits of industrial civilization as creating a ‘captivity’ zone in which humans can live — a zone that isolates us from the insults of the wild. In this captivity zone, the human body naturally hits its lifespan limit shortly after age 100. With intensive medical intervention, the body can survive for a bit longer. And of course, if conditions of war, famine and pandemic intervene, bodies age more rapidly. But in the safety of the captivity zone, we see evidence for a ‘natural’ maximum lifespan.

(Am I confident in this interpretation? No. I’m throwing it out there mostly as an empirical provocation.)

The march towards equality of life

One of the oddities of the human species is that we are the only animal that is cognizant of its own mortality. Perhaps there is a reason for that.

As a rule, animal reproduction is a killing field. For example, when a female salmon lays eggs, [about 99.9%](#) of these potential offspring die before reaching adulthood. Even among our closest evolutionary relative, the chimpanzee, survival to adulthood is generally worse than a coin flip.⁶ So if other animals reflected on their life prospects at birth, they might be horrified at the injustice.

Of course, throughout most of human history, lifespan injustice was the norm. Many children died young, while relatively few people reached old age. Even as recently as the late 20th century, episodes of vast injustice occurred. For example, in the 1980s, South Sudan endured a brutal civil war, in which food blockades were a common weapon. Tens of thousands died in the [ensuing famines](#), with most of the toll paid by children.

In Figure 11, the top panel quantifies the carnage. Here, the red curve plots the age distribution at death in 1988 South Sudan. During the depths of the famine, the majority of the dead were children under age 10. (In that year, life expectancy at birth was just 11 years.)

The good news is that such tragedies are now rare, and the root causes of childhood mortality are easily preventable. The result is that in the wealthiest countries, deaths now pile up on the opposite end of life. The most extreme

⁶[Walker and colleagues](#) estimate that female chimpanzees reach sexual maturity at about age 11. And [Hill and colleagues](#) estimate that about 43% of females survive to this age. For males, the survival rate to age 11 is even worse, at about 37%.

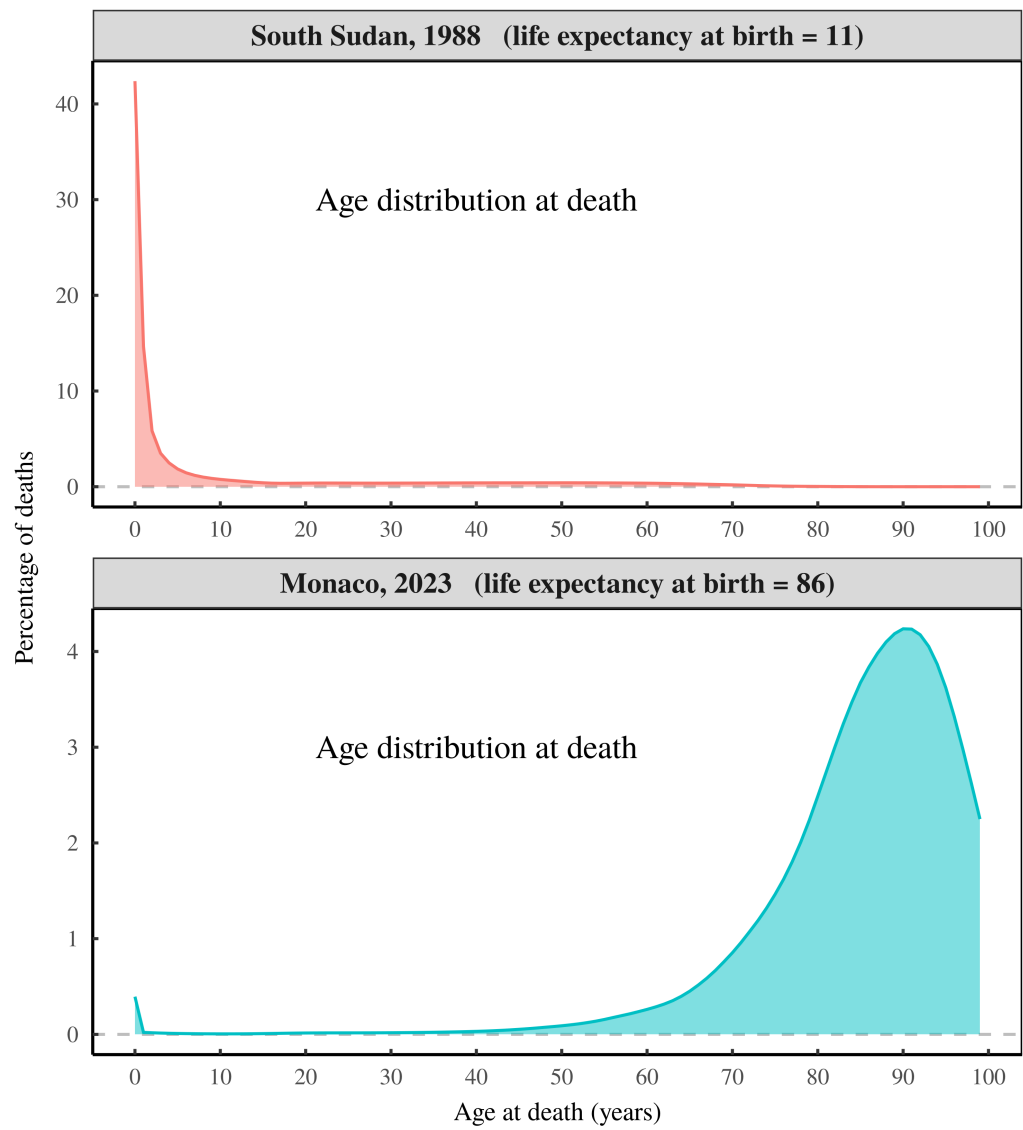


Figure 11: Death at opposite ends of life

This chart shows individuals’ age distribution at death in two regions with opposite extremes. The top panel shows the youth-heavy distribution in South Sudan in 1988 — a year marked by a brutal war-induced famine. The resulting death toll was dominated by children. The bottom panel shows the elderly-heavy death distribution in Monaco in 2023, which has the highest life expectancy on record. [Sources and methods](#)

example of this reversal comes from Monaco in 2023. The bottom panel in Figure 11 shows this demographic upheaval. In modern Monaco, most adults survive to old age, and the most common age at death is 90.⁷

⁷It’s worth noting that Monaco is a tiny city-state that serves as a tax-haven for Europe’s super wealthy. So it’s debatable whether Monaco’s long life expectancy is actually its own accomplishment. It could be more of a migration effect, whereby the (long-lived) super-rich move there to retire. Still, Monaco’s population illustrates the current upper extreme of human life expectancy.

With these two extremes in mind, we should ask ourselves why the famine in South Sudan is considered ‘tragic’, while the old-age pileup in Monaco is not. Yes, the answer to this question is fairly obvious. But let’s go ahead and spell it out.

The human notion of ‘tragedy’ seems to be tied (at least in part) to the existence of plausible counterfactuals. For example, it is ‘tragic’ for children to die of starvation, because the alternative — *not* starving — is easy to envision. Likewise, it is a tragedy when a young parent dies of cancer, because again, we can imagine a world in which the parent survived. But when it comes to death at old age, we find it difficult to imagine an alternative (science fiction notwithstanding). Indeed, for all we know, there *is* no alternative to biological aging. And so we do not consider death from old age a ‘tragedy’. It is simply the natural course of life.

One way to frame this morality is that it describes perhaps the most basic form of human right — the right to die at roughly the same old age. Of course, nature itself cares nothing for this right. But we humans have made it a fundamental social goal. And we have gone a tremendous way towards achieving it.

Let me illustrate this success by quantifying the inequality of the human lifespan, measured with the Gini index. When this Gini index is *high*, individual lifespan is *unequal*; most people die young, while only a lucky few reach old age. In contrast, when the lifespan Gini index is *low*, it indicates that human lifespan is *equal*; most people die at close to the same (old) age.

With this lifespan Gini index in hand, we can quantify what is perhaps the most stunning yet under-recognized pattern in all of demography. It turns out that the task of extending human life expectancy has been a project of bringing remarkable *equality* to the human lifespan. Figure 12 shows this pattern. As life expectancy rises, lifespan inequality falls.⁸

I should add that this wire-tight trend is the sort of pattern that emerges only when there is no social ‘choice’ involved. True, humans choose to extend our lifespans. However, the route we take is non-negotiable. We extend life expectancy almost entirely by keeping the young alive, and not by extending

⁸One way to think about this newfound equality in the human lifespan is that we are now the masters of our own ‘natural’ selection. That is, across all species, the gauntlet of youth is typically a major force for evolution, weeding out the ‘unfit’ long before reproductive age. Today, humans have largely succeeded in removing this selective force. It’s not clear what this achievement means for the future, other than that we are the first species to hold the reins of our own selection.

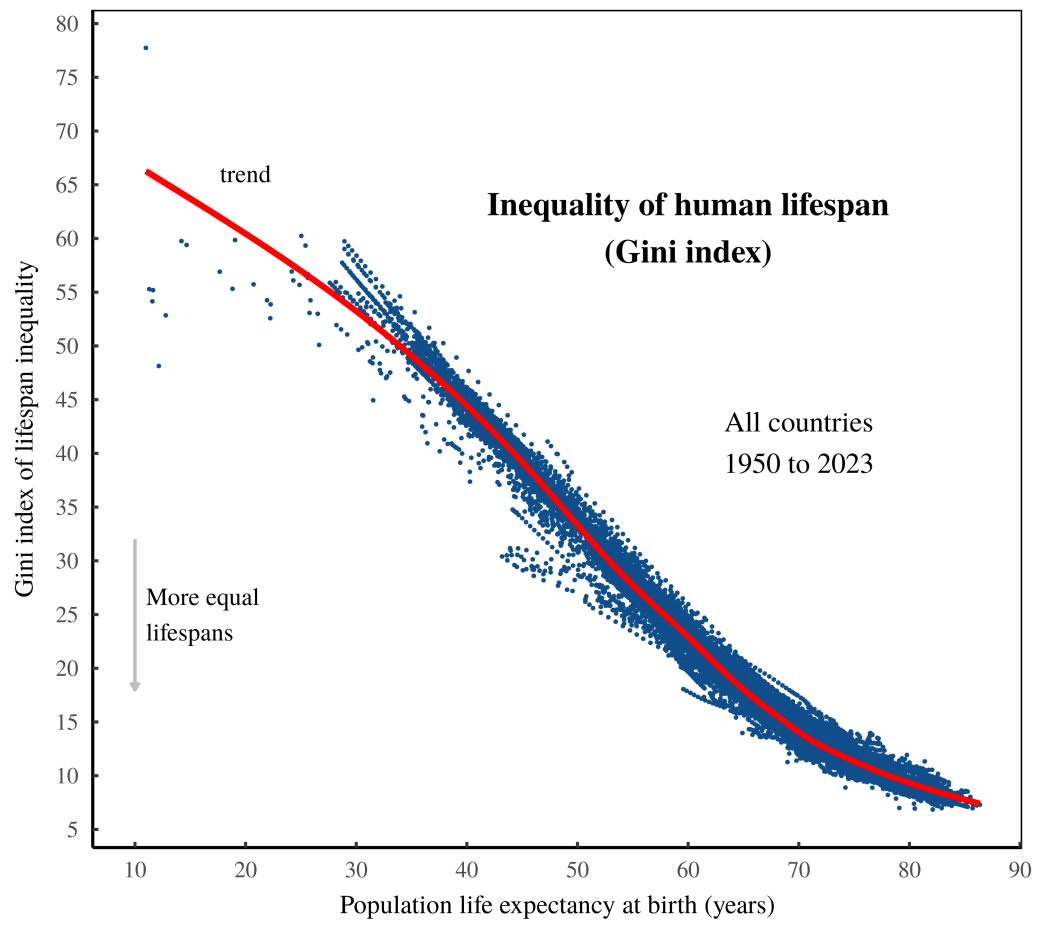


Figure 12: Inequality of the human lifespan

The project of extending human life expectancy is overwhelmingly one of making individual lifespans more equal. Here, the vertical axis shows lifespan inequality among individuals, measured using the Gini index. And the horizontal axis shows population life expectancy at birth. Each point represents a country-year observation measured between 1950 and 2023. When life expectancy is low, most individuals die young while a few live to old age, hence lifespan inequality is high. But when life expectancy is high, most individuals survive to old age, hence lifespan inequality is low. [Sources and methods](#)

the lifespan of the extremely old. The consequence of this non-negotiable strategy is that human lifespan must become more equal as life expectancy increases.

Now, the dream of longevity gurus is to make death at old age *optional*. Of course, there is no hint that the elixir of life exists. But if it were discovered, I think that it would almost surely be disastrous. Let me put it this way. Today’s

billionaires are able to amass extreme wealth. They are able to accumulate immense power. And they are able to bequeath these gains to their children. But the one thing that billionaires cannot do is hoard lifespan itself.

But what if they *could*?

Imagine a world in which CEOs are as immortal as the corporations they command. Imagine a world in which the poor are short-lived, expendable ants. Imagine a world in which lifespan is inherited at birth. I cannot imagine a worse hell.

Of course, it's possible that humans of the future will be able to distribute the fruits of extended living with justness and equality. But then again, given the debauchery of today's elites, this utopia doesn't seem particularly likely. Which is to say that while I would personally be quite pleased to live much longer than a century, I'm quite certain that I won't. Nor, for that matter, will anyone else.

At least for now, I think this human finitude is a good thing.

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Estimating the maximum possible human life expectancy

Here is an intriguing way to estimate the maximum possible human life expectancy. Figure 13 shows how the onset of the old-age gauntlet relates to life expectancy at birth. (This is the same data as in Figure 10.)

Let's suppose that current trends continue. For example, when life expectancy climbs above 70 years, we see that the onset of the old-age gauntlet tends to retreat. Let's imagine that this retreat continues, as illustrated by the red line. While one might think that this extrapolation can rise forever, it actually cannot.

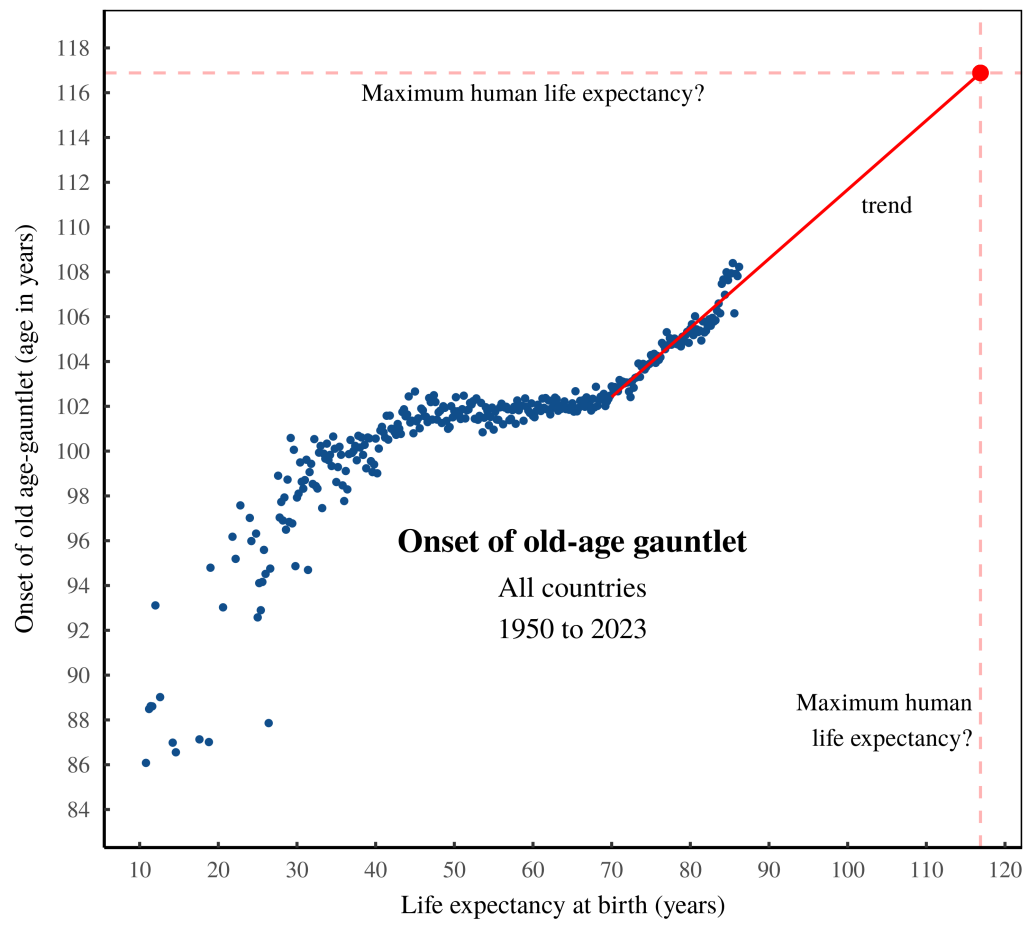


Figure 13: Life expectancy collides with the onset of the old-age gauntlet

Here is a simple way to estimate the maximum possible life expectancy of the human species. Blue points show the empirical relation between the onset of the old-age gauntlet (the age when death becomes more likely than survival) and life expectancy at birth. Suppose we extrapolate the trend on the right, as illustrated by the red curve. This extrapolation hits a logical limit when life expectancy at birth collides with the onset of the old age gauntlet (since the former cannot logically exceed the latter). This collision marks the maximum possible human life expectancy, which I estimate here to be about 117 years. [Sources and methods](#)

The problem is that given current trends, the onset of the old-age gauntlet recedes more slowly than life expectancy advances, leading to an eventually collision in the two values. This collision signals the maximum possible human life expectancy, since by definition, life expectancy cannot significantly exceed the onset of the old-age gauntlet. Given current trends, I estimate that this collision will occur at age 117.

A consistency check

I find it quite intriguing that the onset of the old-age gauntlet has a Z-shape pattern when measured as a function of life expectancy at birth. The caveat is that I'm not confident that this pattern is a 'real' thing.

For example, it's possible that the dynamics of infant mortality somehow 'muddy' patterns which are revealed at old age. One way to remove this effect is to switch from measuring life expectancy at birth to measuring life expectancy at mid-life — say age 40.

As Figure 14 shows, when we make this shift, we still find that the onset of the old-age gauntlet retreats with a Z-shaped pattern (although a more muted one). Interesting, the plateau again occurs at around age 102. Notably, we also find an implied maximum life expectancy, determined by the collision between life expectancy and the onset of the old-age gauntlet. When I extrapolate the right-hand portion of the 'Z' (above the age-forty life expectancy of 35 years), I calculate that this collision will occur at age 123.

Old-age frauds

One last caveat to the analysis here is that the demography of the extremely old is fraught with uncertainty caused by clerical errors and outright fraud. In two recent papers, researcher Saul Justin Newman outlines the reasoning (and the evidence):

- 'Supercentenarian and remarkable age records exhibit patterns indicative of clerical errors and pension fraud'
- 'The global pattern of centenarians highlights deep problems in demography'

The demographic problem stems from the finitude of the human lifespan, and by the fact that exceedingly few people live past age 100. The (unintuitive) consequence is that the population of super-centenarians is likely full of fraudsters.

To see how the math works, consider the following thought experiment. Imagine that among the general population, a tiny fraction of people inflate their age by a decade in order to collect an early pension. At first, these fraudsters are vanishingly rare. But as time passes, the fraudsters become more prominent within their age cohort. That's because, being a decade younger than

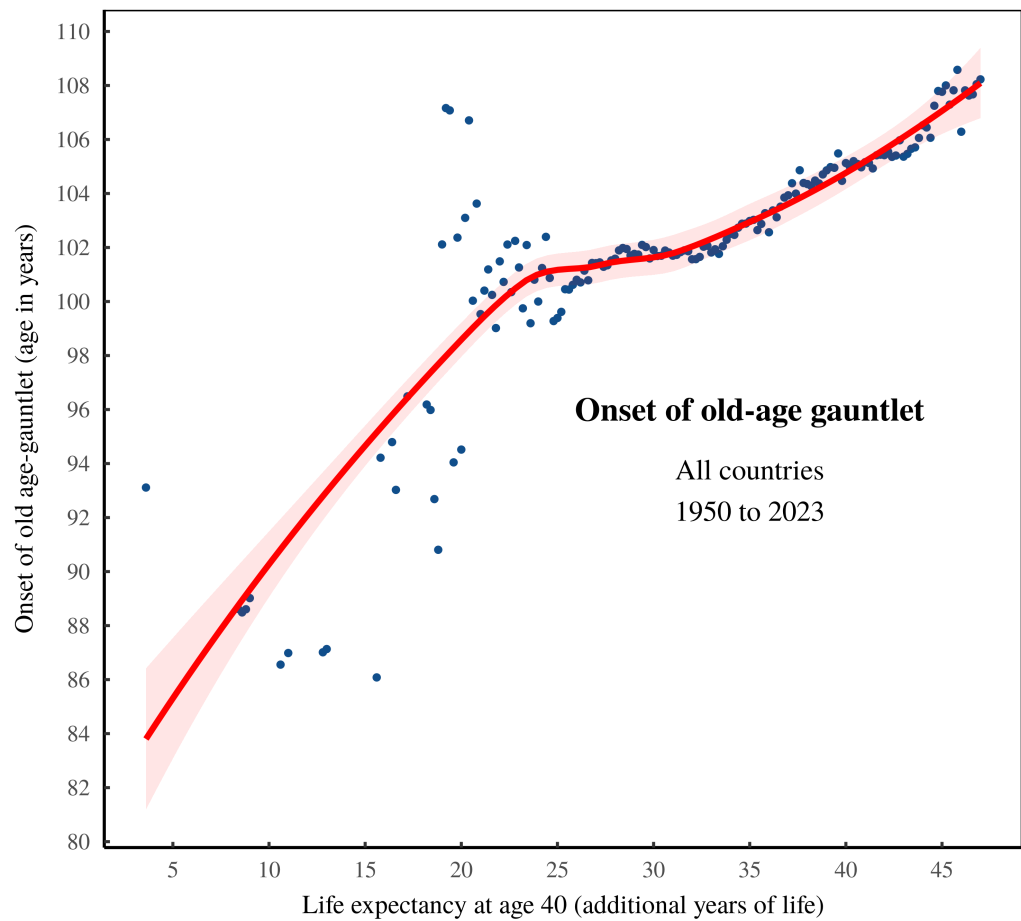


Figure 14: Onset of the old-age gauntlet as a function of life expectancy at age 40

This chart is conceptually the same as Figure 10, except that instead of grouping the mortality-rate data by life-expectancy at birth, I group it by life expectancy at age 40. Within each life-expectancy bin, I then fit a logistic function to age-specific mortality rates about age 70, and use this function to infer the onset of the old-age gauntlet. [Sources and methods](#)

their truth-telling counterparts, the fraudsters have significantly lower death rates. And so with each passing year, more truth-tellers die, leaving behind the population of fraudsters. When we pass the century mark, so many of the truth-tellers have died that only the fraudsters are left. Indeed, it is not unrealistic to think that *everyone* who claims to surpass age 110 is lying.

To back up the claim that many super-centenarians are fraudsters, Newman musters some noteworthy statistics. For example, in the United States, Newman finds that the number of super-centenarians per capita peaked just *before* the introduction of exhaustive birth certificates. And across regions in England, Newman finds that the number of super-centenarians per

capita is associated with several measure of social *ill*. Regions with more super-centenarians tend to have higher crime, greater health deprivation, and bizarrely, fewer people over aged 90. In short, super-centenarians seem to be most common in environments that are conducive to pension fraud. So if you'd like advice about how to reach age 110, probably the best thing you can do is *lie* about your age.

Tellingly, some of the (ostensibly) oldest humans have had rather unhealthy habits. For example, Jeanne Calment, the French woman who is touted as the oldest human ever, [apparently](#) “smoked daily, drank daily, and ate around a kilogram of chocolate a week”. So either Calment was immune to the well-known effects of smoking and drinking ... or she was a complete fraud.

The latter is surprisingly likely. A plausible scenario is that when Calment's mother died in 1934, Calment [assumed her identity](#) to avoid paying inheritance tax. (Calment subsequently destroyed all her family documents.) A few years later, France was upended by the Nazi occupation, which would have made an identity switch easier to achieve. Of course, it is impossible to know the truth about Calment's claims. But I find it more plausible that the smoking/drinking Calment died at the old (but still realistic) age of 99, than to have attained the unheard of age of 122.

At any rate, Newman convincingly argues that scientists who study the extremely old are gripped by a strong dose of wishful thinking, and that demography statistics past age 100 are rife with fraud.

Sources and methods

World life expectancy at birth (Figure 1)

Life expectancy data is from [Our World in Data](#).

US mortality rates by age (Figures 5, 8, and 9)

US age-specific mortality rates in 2021 are from the CDC, National Vital Statistics Reports. I used data from Table01, conveniently buried on this [FTP server](#). I used series qx for age-specific mortality rates.

International life tables

All other charts in this essay use life-table data from the United Nations [World Population Prospects 2024](#). I used the table ‘Single age life tables up to age 100 - Both Sexes’. Specific calculations are as follows:

- **World life expectancy at age 100** (Figure 2): Series ex gives life expectancy by age for each country/year. I calculate the global life expectancy at age 100 by averaging across countries, weighted by their population. I use population data from [Our World in Data](#).
- **Life expectancy at birth**: series ex (life expectancy by age) measured at age 0.
- **Infant mortality rate** (Figure 3): series qx (age-specific probability of dying) measured at age 0.
- **Mortality rate at age 99** (Figure 4): series qx (age-specific probability of dying), measured at age 99.
- **Mortality-rate curves by population life expectancy** (Figure 6): mortality-rate curves use series qx (age-specific probability of dying). To smooth the mortality curves, I bin the qx data by life expectancy at birth, grouped into life-expectancy intervals of 0.2 years. Then I take the age-specific geometric mean of the qx data within each life-expectancy bin. In Figure 7, I normalize these curves against the data for life expectancy = 35 years.
- **Onset of the old-age gauntlet** (Figure 10 and 13): First, I use the steps above to average the age-specific mortality-rate data (qx) by life expectancy bins. Then within each bin, I keep data for age 70 and up. If this empirical data contains a point where mortality rates exceed 50%, I use the R approx function to infer the exact onset of the old-age gauntlet. If the empirical mortality-rate data never crosses the 50% threshold, I fit it with a logistic function (defined by the R function plogis). I then estimate the onset of the old-age gauntlet using the best-fit logistic function.
- **Old-age gauntlet consistency check** (Figure 14): I use the same steps as for Figure 10, but instead of binning the data by life expectancy at birth, I bin it by life expectancy at age 40. From there, the same methods apply.

- **Age distribution at death** (Figure 11): I use series dx — number of deaths by age. 1988 South Sudan and 2023 Monaco have the lowest and highest (respectively) life expectancies recorded in the UN data.
- **Gini index of individual lifespan** (Figure 12): I calculate the Gini index of individual lifespan using series dx — number of deaths by age. (The age distribution at death is equivalent to the distribution of individual lifespans in the given year.) To calculate the Gini index, I first create a Lorenz curve for the age distribution at death. From this Lorenz curve, I measure the Gini index by calculating the [area under the curve](#). (To calculate this area, I use the `auc` function from the R library `pracma`.)

Note that because the empirical data is bounded at age 100, it introduces a slight bias in the lifespan Gini index for regions with a high life expectancy. (You can see this bias in Figure 11, where the age distribution at death in Monaco ends abruptly at age 100.) In Figure 12, I've corrected for this problem by fitting the empirical mortality-rate data (qx in each country/year) with a logistic function, and then using this function to extrapolating the dx series well past age 100. It is a fun exercise in computation, but one that actually makes virtually no difference to the resulting lifespan Gini indexes.

Further reading

- Newman, S. J. (2019). Supercentenarian and remarkable age records exhibit patterns indicative of clerical errors and pension fraud. *bioRxiv*.
- Newman, S. J. (2024). The global pattern of centenarians highlights deep problems in demography. *medRxiv*.