The Variance of Human Lifespans

Mean, Median, and Especially the *Spread* of Ages at Death, across Time and Space

Claude Code

June 28, 2026

Abstract

"Life expectancy at birth" (e_0) is a single number—the *mean* of the distribution of ages at death implied by a period life table. This report studies the rest of that distribution, and above all its *variance*: how unequally lifespans are distributed within a population, a quantity demographers call *lifespan variation* or *lifespan inequality*. We compute the mean (e_0), the median age at death, and a battery of dispersion measures—variance and standard deviation (SD), coefficient of variation, interquartile range, the Gini coefficient of the life table, life disparity ($e^\dagger$), and Keyfitz's entropy (H)—from 123,210 life tables spanning 553 populations (237 countries plus the World and regional aggregates) for every year 1950–2023, extended back to 1790 for the United States using reconstructed historical life tables. The central finding is stark and robust: the spread of human lifespans has collapsed. In the United States the standard deviation of age at death fell from roughly 31 years across the nineteenth century to about 16.6 years in 2023; for the world as a whole it fell from 30.9 years in 1950 to 21.7 years in 2023. This compression is driven overwhelmingly by the conquest of infant and child mortality: conditional on surviving to age 10, US lifespan variation has barely moved since 1950. Across all countries and years, lifespan variation falls almost mechanically as life expectancy rises—one of the tightest regularities in demography—though the United States is a conspicuous high-variance outlier among rich nations, and the COVID-19 pandemic (2020–21) and the "deaths of despair" era visibly *raised* American lifespan inequality. We document every data source, evaluate its coverage and methodology, validate our computations against the published literature, and release a fully reproducible pipeline.

Contents

1 Introduction

Few numbers are quoted more often than "life expectancy at birth." When we read that US life expectancy is 79 years or that Japan's is 85, it is easy to forget what the figure actually is: the *arithmetic mean* of a whole distribution—the distribution of ages at which the members of a hypothetical birth cohort would die if they experienced a given year's mortality rates at every age. That distribution has a median, a mode, a shape, and crucially a *spread.* Two populations can share an identical life expectancy while differing enormously in how *equally* that expectancy is distributed: one in which almost everyone dies near age 80, and another in which a third die in infancy while the rest live to ninety, can have the same mean.

This report is about that spread—the **variance of the age-at-death distribution**, known in demography as *lifespan variation*, *lifespan inequality*, or *length-of-life inequality.* It is, as van Raalte et al. (2018) put it, "the most fundamental of all inequalities," because every other inequality between persons is conditional on their being alive to experience it. Our brief was to estimate, for every year of US history for which data can be found or reconstructed, and for as many other countries (and the world as a whole) as possible, the *mean, median, and especially the variance* of life expectancy at birth, together with a transparent account of every data source and how the sources are combined.

Two senses of "variance," both addressed. The phrase "the variance of life expectancy at birth" admits two readings, and we treat both:

1. **The variance of the age-at-death distribution** (our primary subject). Here "life expectancy at birth" is the *mean* of a distribution, the median age at death is its *median*, and the variance measures the dispersion of lifespans *within* a population in a given year. One distribution, three moments—this is the natural and demographically rich reading, and the bulk of this report.

2. **The variance of e_0 across space** (a secondary reading). How dispersed are *national* life expectancies across countries in a given year? This is "variation across space" in the literal sense, and we document it in section 5.5: it has fallen sharply since 1950 as poor countries caught up.

What we find. The headline results, developed in section 5, are:

- **Lifespan variation has collapsed.** The standard deviation of age at death in the United States fell from ≈ 31 years across the nineteenth century to ≈ 16.6 years in 2023; the world's fell from 30.9 years (1950) to 21.7 years (2023). Survival curves have "rectangularized" and deaths have compressed into a narrow old-age peak.

- **Infant and child mortality did it.** Conditional on surviving to age 10, US lifespan variation has been almost flat since 1950 ($SD_{|10} \approx 15$ years throughout). The historical decline in total variation is almost entirely the disappearance of early-life deaths.

- **A near-mechanical regularity.** Across every country-year, lifespan variation falls as e_0

rises (fig. 7). The two move together so tightly that lifespan *equality* and life *expectancy* are nearly the same story (Colchero et al., 2016; Aburto et al., 2020).

- **The United States is an outlier, and recently a cautionary tale.** Among rich countries the US has unusually high lifespan inequality (SD = 16.6 vs. ≈ 12.5–13.4 for Japan, Sweden, Switzerland, South Korea). The 2010s stagnation ("deaths of despair") and the COVID-19 shock *raised* US variation: SD rose from 16.7 (2019) to 17.4 (2021) as e_0 fell by 2.5 years.

2 Concepts and Measures

2.1 From a life table to a distribution

A *period life table* for a given population and calendar year takes the observed age-specific mortality rates m_x and converts them into a synthetic cohort: ℓ_x, the number surviving to exact age x from a radix ℓ_0 (here 100,000); $d_x = \ell_x - \ell_{x+n}$, the number dying in the age interval $[x, x+n)$; L_x, person-years lived in the interval; and e_x, remaining life expectancy at age x, so that e_0 is life expectancy at birth. The column d_x *is* the age-at-death distribution of the synthetic cohort (fig. 1). Every quantity in this report is a functional of d_x.

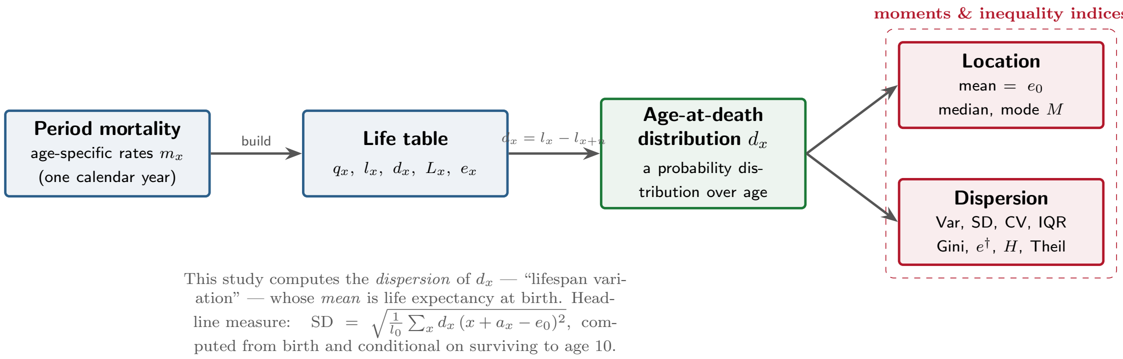

Figure 1: From period mortality rates to the moments and inequality indices of the age-at-death distribution. The *mean* of d_x is life expectancy at birth; this study targets its *dispersion*.

Throughout, we write the representative age at death within an interval as $\alpha_x = x + a_x$, where a_x (the "${}_n a_x$") is the average time lived in the interval by those who die in it; for single-year intervals $a_x \approx 0.5$, while for infants $a_0 \approx 0.1$–0.3 (Andreev and Kingkade, 2015). Let $\eta = e_0$ be the mean age at death.

2.2 The measures

We compute the following, each in an absolute (years) or relative (dimensionless) flavour. Full discrete formulas are collected in section A; the canonical references are Wilmoth and Horiuchi (1999), Shkolnikov et al. (2003), Vaupel and Canudas-Romo (2003), and van Raalte and Caswell (2013).

Mean e_0, life expectancy at birth $= \frac{1}{\ell_0} \sum_x d_x \, \alpha_x$.

Median the age to which exactly half the radix survives, $\ell_x/\ell_0 = 0.5$.

Modal age M the most common adult age at death (Kannisto, 2001); meaningful only for single-year tables.

Variance / SD $\sigma^2 = \frac{1}{\ell_0}\sum_x d_x(\alpha_x - \eta)^2$, $\mathrm{SD} = \sigma$. The headline absolute measure, in years.

Coefficient of variation $\mathrm{CV} = \mathrm{SD}/\eta$, scale-free.

Interquartile range $\mathrm{IQR} = x_{0.25} - x_{0.75}$, the age span between the quartiles of the survival curve (Wilmoth and Horiuchi, 1999); robust to the tails.

Life disparity $e^\dagger = \frac{1}{\ell_0}\sum_x d_x\,\bar{e}_x$, the average remaining life expectancy lost to death (Vaupel and Canudas-Romo, 2003); absolute, in years.

Keyfitz's entropy $H = e^\dagger/e_0$, the elasticity of e_0 to a proportional change in mortality (Keyfitz, 1977; Leser, 1955); $H \to 0$ as the survival curve becomes rectangular, $H \to 1$ under a constant hazard.

Gini coefficient G of the life table (Shkolnikov et al., 2003): half the mean absolute difference in lifespan between two random individuals, divided by e_0.

2.3 Conditioning and the threshold age

Because early-life deaths sit "far" from the adult mean, they dominate every dispersion index when child mortality is high. It is therefore standard to report variation both *from birth* and *conditional on surviving to a threshold age* (we use age 10), which re-bases the life table to radix ℓ_{10} and recomputes the measures over deaths at ages ≥ 10. The gap between the two is, in effect, the contribution of infant and child mortality (fig. 4). Relatedly, each index has a *threshold age* $a^\dagger$ at which a marginal mortality reduction switches from *compressing* to *expanding* lifespan variation (van Raalte and Caswell, 2013): saving the young equalises lifespans, while saving the already-old stretches them. In modern low-mortality populations almost all remaining mortality lies above $a^\dagger$, which is why further gains in e_0 no longer automatically compress lifespans.

3 Data Sources

Computing the *variance* of age at death requires the full death distribution d_x (or equivalently ℓ_x), not merely e_0. This sharply constrains the usable sources: long runs of e_0 exist back to the eighteenth century, but life *tables* are scarcer. We surveyed eight sources, summarised in table 1, and combined them as in fig. 2.

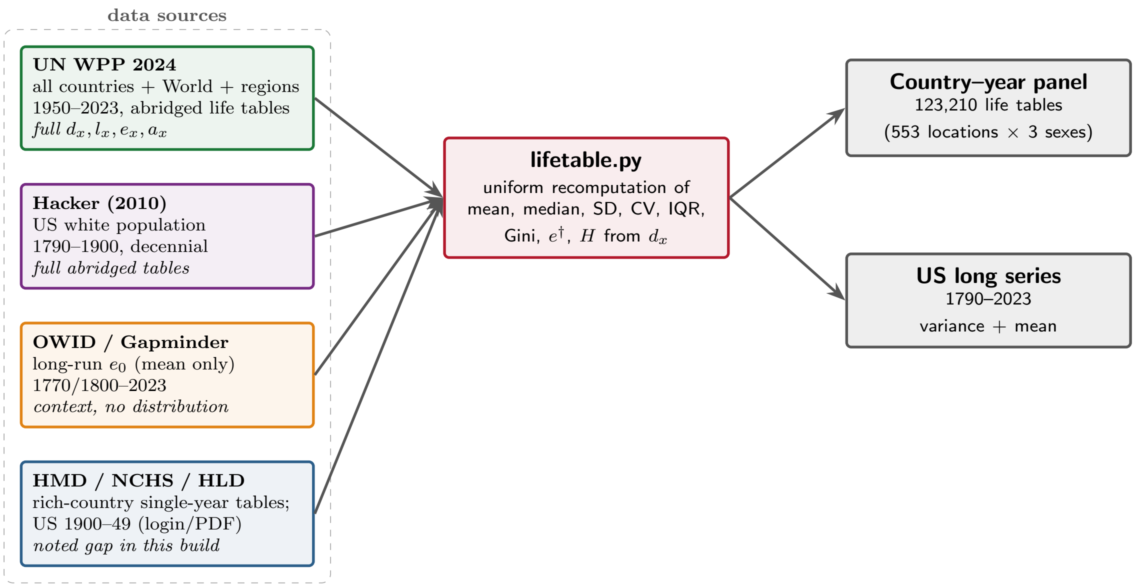

Figure 2: How the sources are combined. A single computational engine recomputes every measure from d_x on a uniform definition, so that figures are comparable across sources despite their different provenance.

Table 1: Data sources evaluated. "Dist." = provides the death distribution (d_x/ℓ_x) needed for variance; "e_0 only" sources give the mean but no spread.

Source	Coverage	Years	Dist.?	Role here
UN WPP 2024	all countries, World, regions	1950–2023	yes	**primary backbone**
Hacker (2010)	US white pop. (decennial)	1790–1900	yes	**US deep history**
HMD	≈41 rich countries	1751–2023	yes	login-gated; unused
NCHS / SSA	United States, official	1900–2023	yes	US 1900–49 (gap)
HLD	≈140 countries	1751–2018	yes	supplementary
Eurostat	EU/EFTA, single-year	1960s–2023	yes	supplementary
OWID	all countries + World	1543–2023	no	long-run e_0 context
Gapminder	all countries + World	1800–2100	no	long-run e_0 context

UN World Population Prospects 2024 (primary). The 28th UN revision provides abridged period life tables (age groups 0, 1–4, 5–9, . . . , 95–99, 100+) for 237 countries and territories plus the World and dozens of regional aggregates, by sex and both sexes, annually for 1950–2023. Critically for us, the published file includes the full columns $m_x, q_x, \ell_x, d_x, L_x, T_x, e_x$ *and* a_x, so within-interval death placement is handled exactly rather than by a crude midpoint assumption. Mortality is estimated from vital registration, censuses, surveys, and UN-IGME child-mortality inputs, then smoothed and projected with a modified Lee–Carter/SVD model; the "Medium" variant is the median of a probabilistic ensemble (United Nations, Department of Economic and Social Affairs, Population Division, 2024). We downloaded the single open 138 MB file (`WPP2024_Life_Table_Abridged_Medium_1950-2023.csv.gz`, 2.71 million rows; CC BY 3.0 IGO) and computed measures for all 123,210 life tables it contains. *Limitations:* period (not cohort) tables; values for data-poor countries are model-smoothed; the abridged grouping mildly coarsens the death distribution (mitigated by the supplied a_x); and the open 100+ interval requires a tail-closure assumption.

Hacker (2010), US white population 1790–1900 (deep history). To push the US series back beyond the modern record, we use the decennial life tables that Hacker (2010) reconstructed for the white population by fitting a two-parameter logit (Brass) relational model to standards anchored on the 1900–1902 registration-area tables, incorporating best estimates of e_{20} by decade. The open-access version of the paper publishes full abridged life tables (with $q_x, \ell_x, d_x, L_x, T_x, e_x$) for white males and white females in each decade 1790–99 through 1890–99; we parsed these directly, derived a_x from the published L_x, and combined the sexes using the birth sex ratio. This yields e_0, the median, SD, and all inequality indices for 11 decennial points. *Limitations:* the *white* population only (Black and enslaved mortality was substantially higher and is separately, more poorly documented before 1900); decennial, not annual; and model-reconstructed, with the largest uncertainty in the under-5 mortality that dominates early-era variance. Our extracted e_0 values reproduce Hacker's published series, including the well-known antebellum mortality *deterioration* (a fall to $e_0 \approx 37$ around 1850).

Sources used for context or noted as gaps. *Our World in Data* and *Gapminder* supply continuous e_0 (the mean line) for the US back to 1800 and the World back to the eighteenth century, but no death distribution—useful backdrop, useless for variance (Roser et al., 2023; Gapminder, 2023). The *Human Mortality Database* (Human Mortality Database, 2024) is the gold standard for single-year tables (Sweden from 1751; US 1933–), but now requires an authenticated login that precludes automated, reproducible download; we therefore do *not* use it, and the resulting gap—annual US full life tables for 1900–1949—is left explicit in our US figures rather than papered over. That window is in principle covered by the official *NCHS* decennial volumes and *SSA* Actuarial Study 120 (Glover, 1921; Bell and Miller, 2005), which are public but PDF-only; extracting them is left to future work. The *Human Life-Table Database* (Human Life-Table Database, 2024), *Eurostat*, and *GBD* 2021 (GBD 2021 Demographics Collaborators, 2024) are open and distribution-bearing and would extend rich-country and historical coverage further.

4 Methodology

A single computational engine. All measures are computed by one module (`lifetable.py`) applied uniformly to every source, so that a US figure for 1850 and a Nigeria figure for 2023 are defined identically. Given a life table, we treat d_x/ℓ_0 as a probability mass over the representative ages $\alpha_x = x + a_x$ and evaluate the discrete formulas of section A. When a source supplies a_x (WPP) we use it; when it supplies L_x (Hacker) we invert $L_x = n\,\ell_{x+n} + a_x d_x$ for a_x; otherwise we default to interval midpoints with an Andreev–Kingkade infant correction (Andreev and Kingkade, 2015). The open interval contributes $\alpha = x + e_x$. Conditioning on age 10 re-bases the radix to ℓ_{10}.

Abridged vs. single-year tables. Variance, SD, CV, IQR, Gini, $e^\dagger$ and H are all well-behaved on abridged (5-year) tables provided a_x is respected—indeed the life-table Gini estimator of Shkolnikov et al. (2003) is designed for abridged data with an open terminal group. Only the modal age M genuinely requires single-year resolution, so we report it sparingly.

Combining sexes. Where only sex-specific tables exist (Hacker), we form a both-sexes table by mixing the male and female survivorship in birth-ratio proportions (1.05:1) before recomputing d_x and the measures—the correct period combination, rather than averaging summary statistics.

Validation. The engine reproduces analytic benchmarks exactly: for a constant-hazard (exponential) schedule it returns CV $= 1$, $H = 1$, and $G = 0.5$ to three decimals. Against the empirical literature, our 2020 values land squarely on published figures: SD of age at death $= 13.6$ (Japan), 12.8 (Sweden), 16.8 (United States), and 21.7 (World), with US life disparity $e^{\dagger} \approx 12$ years—all consistent with Vaupel et al. (2011) and Aburto et al. (2020). We regard the cross-source comparability as good to within the intrinsic differences in how the underlying tables were built.

5 Results

5.1 The United States, 1790–2023

Figure 3 and table 2 tell the central story. Across the entire nineteenth century the standard deviation of age at death for the US white population hovered around 30–31 years—roughly *double* today's value. Life expectancy itself was not monotone: it fell from ≈ 44 years in the 1790s to a trough of ≈ 37 years around 1850 (the "antebellum puzzle" of mortality worsening amid early urbanisation and epidemic disease), before recovering to ≈ 50 by the 1890s. Strikingly, lifespan variation barely responded to these swings in the mean, because it was pinned by pervasive infant and child mortality.

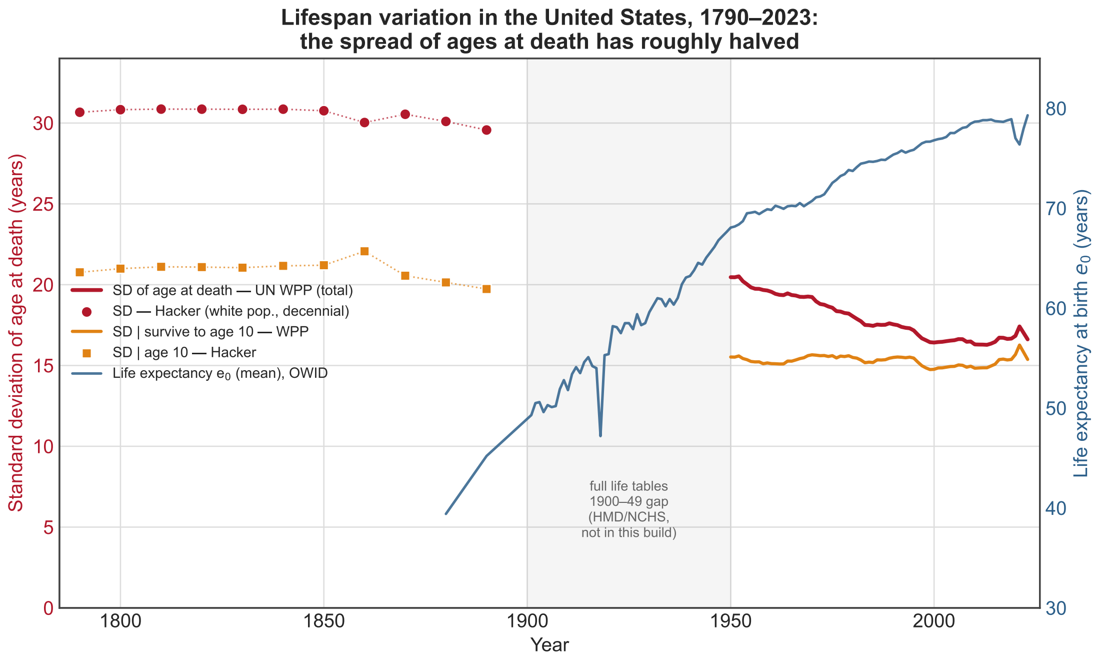

Figure 3: Lifespan variation in the United States, 1790–2023. The SD of age at death (red) roughly halved; the SD conditional on surviving to age 10 (orange) fell far less, showing that the collapse of *total* variation was the collapse of early-life mortality. Life expectancy e_0 (blue, right axis) shows the 1918 influenza dip and the 2020 COVID dip. The 1900–49 window (shaded) lacks full annual life tables in this build.

Table 2: United States: mean, median, and dispersion of the age-at-death distribution, selected years. 1790–1890 are Hacker's white-population reconstructions; 1950–2023 are UN WPP (total population). $SD_{|10}$ conditions on survival to age 10.

Year	Pop.	e_0	Median	SD	$SD_{\|10}$	CV	Gini	$e^\dagger$
1790	white	44.1	51.6	30.7	20.8	0.695	0.394	24.8
1830	white	40.7	45.0	30.8	21.1	0.759	0.431	25.6
1850	white	37.0	37.1	30.8	21.2	0.832	0.471	26.1
1870	white	43.9	51.2	30.5	20.6	0.695	0.394	24.8
1890	white	50.3	60.2	29.6	19.7	0.588	0.327	22.9
1950	total	68.1	72.8	20.5	15.5	0.301	0.153	14.5
1970	total	70.7	74.9	19.2	15.7	0.272	0.140	13.9
1990	total	75.4	79.0	17.5	15.5	0.233	0.120	12.8
2000	total	76.8	80.4	16.4	14.8	0.214	0.109	11.9
2010	total	78.7	82.4	16.3	14.8	0.207	0.106	11.7
2019	total	78.9	82.9	16.7	15.4	0.211	0.108	11.9
2021	total	76.4	80.6	17.4	16.3	0.228	0.119	12.8
2023	total	79.3	83.4	16.6	15.4	0.210	0.107	11.9

Once the modern record begins (1950), the SD of age at death falls steadily from 20.5 to about 16.3 years by 2010. But the conditional measure $SD_{|10}$ is nearly flat over the same period (≈ 15 years)—direct evidence that essentially *all* of the post-1950 compression came from averting deaths before age 10 (fig. 4). After 2010 the US story turns adverse: SD edged *up* from 16.3 (2010) to 16.7 (2019) during the "deaths of despair" stagnation, then jumped to 17.4 in 2021 as COVID-19 cut e_0 by 2.5 years—a vivid reminder that mortality shocks concentrated at working ages *raise* lifespan inequality. By 2023 both had partly recovered ($e_0 = 79.3$, SD = 16.6).

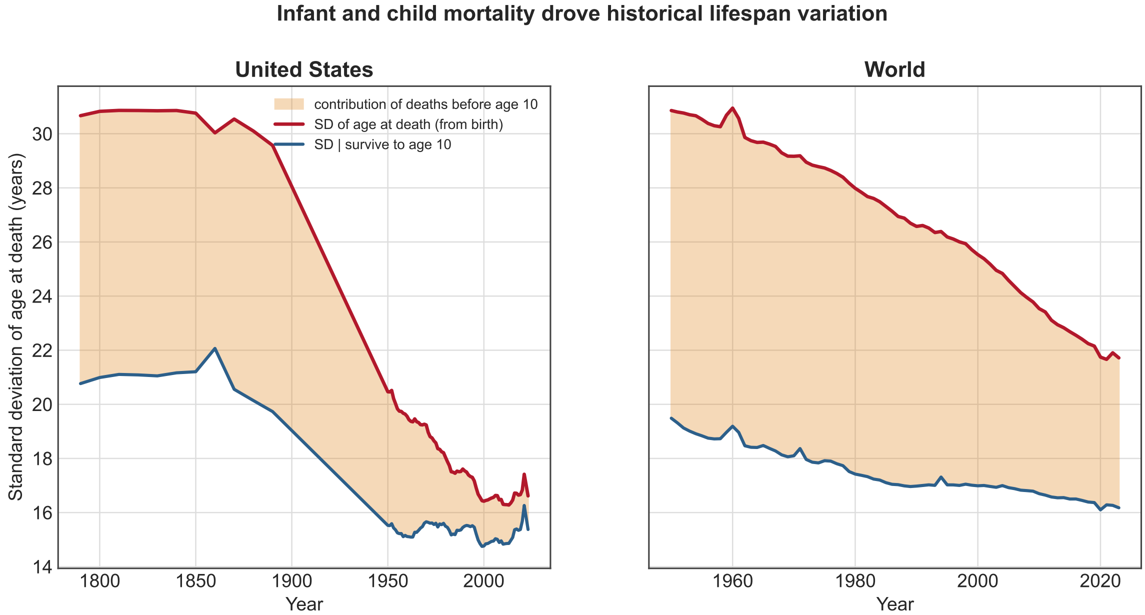

Figure 4: The shaded band is the contribution of deaths before age 10 to total lifespan variation. It once dominated and has now nearly vanished in the US, while remaining substantial for the World.

5.2 The shape of death: rectangularization and compression

Figure 5 shows *why* the summary numbers move. In the nineteenth-century US the survival curve was concave—a fifth of newborns died before age 1, and attrition continued steadily—so the death distribution was bimodal, with an enormous infant spike and a low, broad adult hump. As mortality fell, the survival curve became *rectangular* (almost everyone now survives to old age) and deaths *compressed* into a narrow peak around the modal age, which for Japan in 2023 sits near 88. This is the "rectangularization" first debated by Fries (1980) and quantified by Wilmoth and Horiuchi (1999); our figures reproduce their finding that compression, having largely exhausted the infant-mortality dividend, slowed after mid-century.

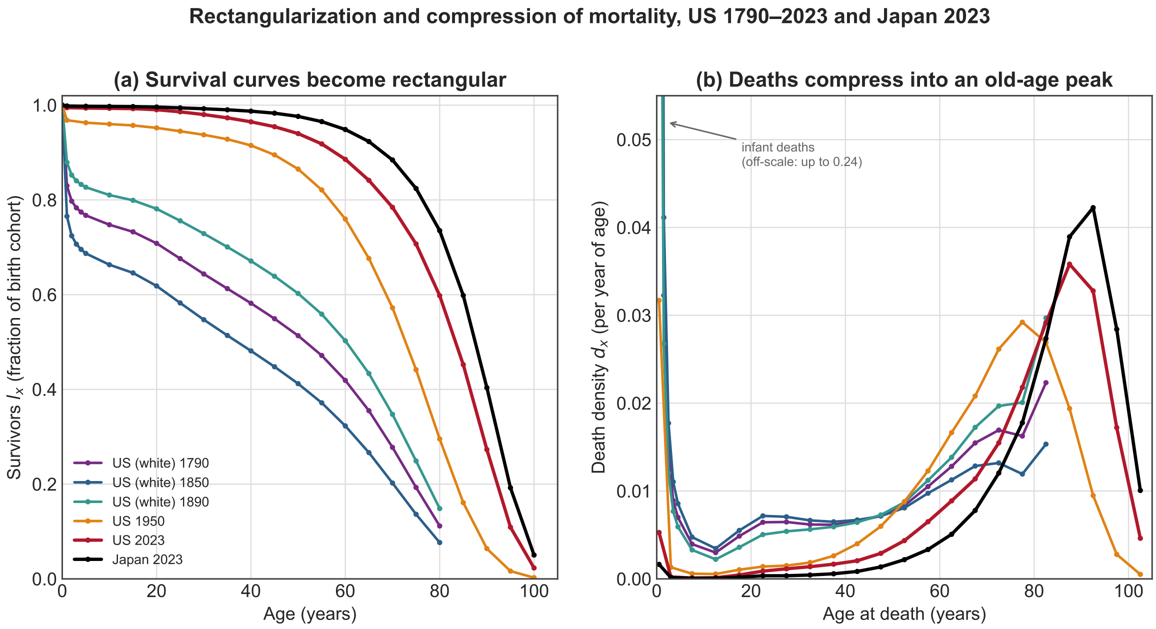

Figure 5: (a) Survival curves ℓ_x becoming rectangular; (b) the death density d_x compressing into an old-age peak. US white population 1790/1850/1890 (Hacker), US 1950/2023 and Japan 2023 (WPP).

5.3 The world as a whole

Aggregated to the World (fig. 6, table 3), the same compression appears on a global canvas. Between 1950 and 2023 world e_0 rose from 46.4 to 73.2 years while the SD of age at death fell from 30.9 to 21.7 years, life disparity $e^\dagger$ fell from 24.2 to 14.7 years, and Keyfitz's H more than halved (0.522 to 0.200). The world in 2023 has roughly the lifespan variation that the now-low-variance rich countries had decades ago; its remaining excess over those countries is, again, mostly unfinished business in child survival.

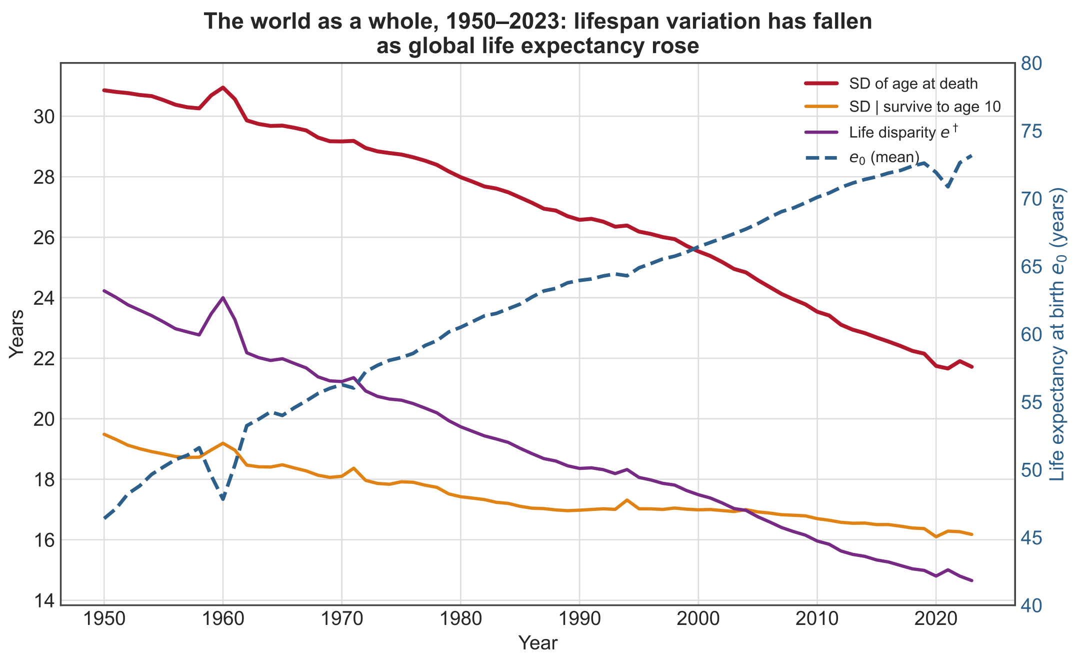

Figure 6: The world, 1950–2023: every measure of lifespan variation has fallen as global e_0 rose.

Table 3: World aggregate (both sexes), selected years (UN WPP 2024).

Year	e_0	Median	SD	$SD_{\|10}$	CV	Gini	$e^\dagger$	H
1950	46.4	56.4	30.9	19.5	0.665	0.373	24.2	0.522
1960	47.8	58.5	30.9	19.2	0.647	0.361	24.0	0.502
1970	56.3	66.6	29.2	18.1	0.518	0.280	21.2	0.377
1980	60.5	70.1	28.0	17.4	0.463	0.244	19.7	0.326
1990	64.0	72.4	26.6	17.0	0.416	0.215	18.4	0.287
2000	66.4	74.2	25.5	17.0	0.384	0.197	17.5	0.263
2010	70.1	76.7	23.5	16.7	0.336	0.169	16.0	0.228
2019	72.6	78.5	22.2	16.4	0.305	0.152	15.0	0.206
2021	70.9	76.3	21.7	16.3	0.306	0.155	15.0	0.212
2023	73.2	78.9	21.7	16.2	0.297	0.148	14.7	0.200

5.4 Across countries: the central regularity

Pooling all 237 countries for all years 1950–2023 (fig. 7) reveals one of the tightest relationships in demography: lifespan variation falls as life expectancy rises. The cloud of ≈ 17,000 country-years traces a single descending curve, and the historical US trajectory slots neatly onto its upper-left continuation. The relationship is so tight that Colchero et al. (2016) and Aburto et al. (2020) treat lifespan *equality* and life *expectancy* as two facets of one underlying process—the progressive postponement of death, achieved first and most powerfully by saving the young.

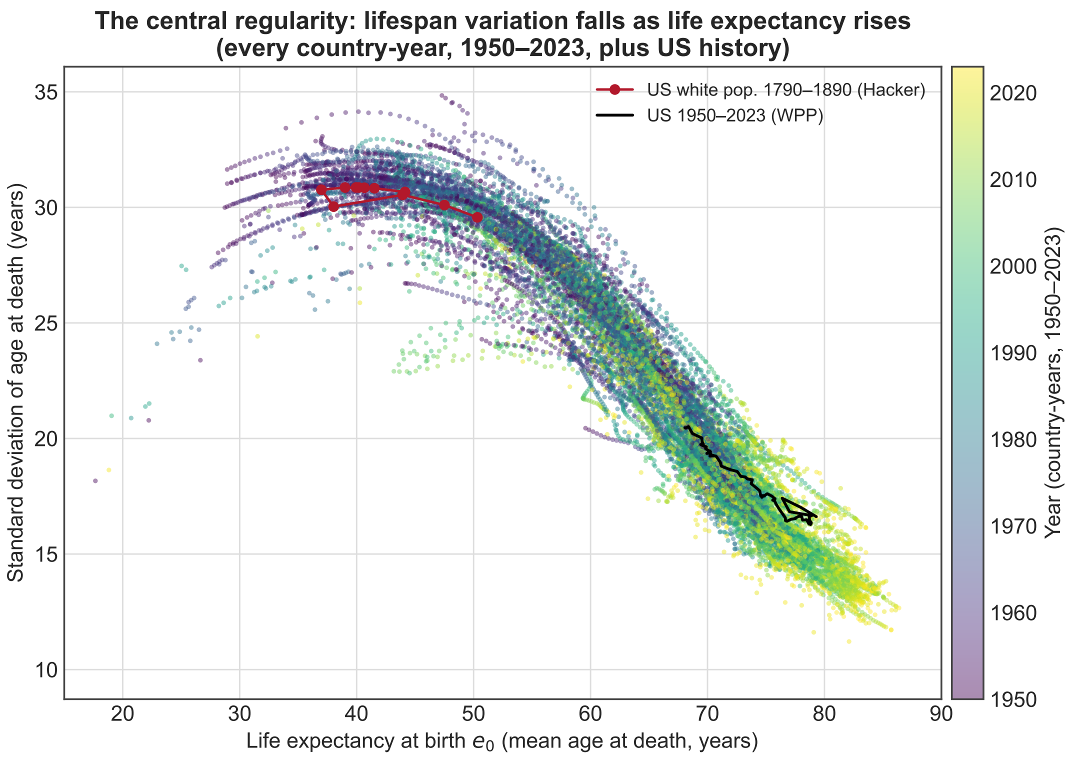

Figure 7: Every country-year, 1950–2023 (coloured by year), plus the US historical trajectory. Lifespan variation (SD) declines as e_0 rises; the peak variation occurs at intermediate e_0.

Yet the regularity is not destiny, and the spread *around* it is informative (table 4). At a 2023 life expectancy near 79–85, the lowest-variance countries—Japan, South Korea, Switzerland, Sweden, Australia, Italy—cluster at SD ≈ 12.4–13.4 years, while the **United States sits at 16.6 years**, a remarkable excess of ≈ 3–4 years of lifespan inequality over its income peers. This is the quantitative signature of the much-discussed American mortality disadvantage: relative to other rich democracies, Americans die across a much wider band of ages. Figure 8 shows the national time paths underlying the pooled cloud, including the post-Soviet mortality crisis (Russia) and rapid convergence (South Korea, China).

Table 4: Mean, median, and dispersion of the age-at-death distribution, selected countries, 2023 (both sexes, UN WPP 2024). Countries are ordered from lowest to highest lifespan variation.

Country (2023)	e_0	Median	SD	CV	Gini	$e^\dagger$	H
Japan	84.7	87.5	13.4	0.158	0.080	9.6	0.114
Switzerland	84.0	86.7	12.9	0.154	0.076	9.0	0.107
Sweden	83.3	86.0	12.9	0.155	0.077	9.2	0.110
South Korea	84.3	86.3	12.4	0.147	0.075	9.4	0.111
Australia	83.9	86.6	12.5	0.149	0.076	9.1	0.108
Italy	83.7	86.4	12.7	0.151	0.076	9.1	0.108
United States	79.3	83.4	16.6	0.210	0.107	11.9	0.149
China	78.0	81.1	14.8	0.190	0.094	10.4	0.133
Mexico	75.1	79.5	18.3	0.244	0.126	13.1	0.175
Russia	73.2	76.8	18.0	0.247	0.134	14.0	0.192
India	72.0	75.9	19.2	0.266	0.134	13.6	0.189
Nigeria	54.5	63.7	27.7	0.508	0.281	20.9	0.384
Cent. African Rep.	57.4	64.4	26.1	0.454	0.249	19.8	0.345
World	73.2	78.9	21.7	0.297	0.148	14.7	0.200

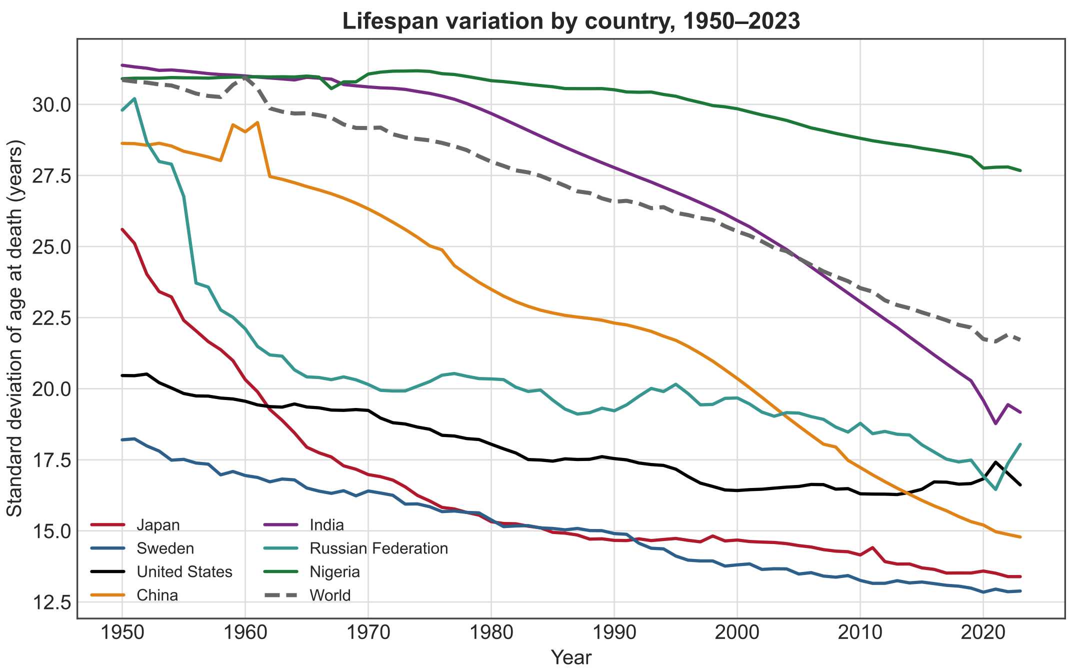

Figure 8: Standard deviation of age at death by country, 1950–2023.

5.5 Variation across space

Finally, the second reading of "variance"—the dispersion of *national* life expectancies across countries—is shown in fig. 9. Here too variation has fallen: the cross-country standard deviation of e_0 dropped from 11.7 years in 1950 to 7.0 years in 2023 as poorer countries closed much of the gap, with temporary reversals visible around the 1990s (the HIV/AIDS epidemic and the post-Soviet collapse). Between-country inequality in length of life has narrowed even as, within many countries, the United States included, within-population inequality has proven stubborn.

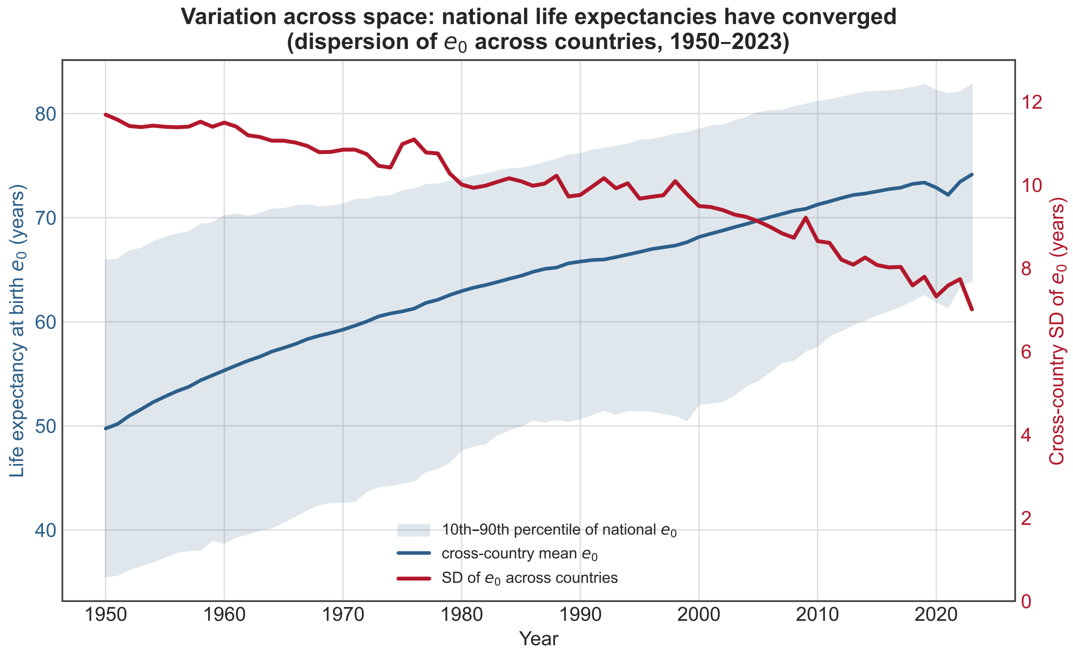

Figure 9: Variation across space: the dispersion of national life expectancies, 1950–2023. National e_0 values have converged (cross-country SD falling from 11.7 to 7.0 years).

6 Discussion

Why mean and variance move together. The coupling in fig. 7 is not a coincidence but a near-arithmetic consequence of *where* mortality falls. Because deaths in infancy are maximally distant from the adult mean, removing them simultaneously raises e_0 and shrinks every dispersion index; this is the content of the threshold-age result of van Raalte and Caswell (2013) and the pace-of-aging synthesis of Aburto et al. (2020). The corollary is sobering for rich countries: once child mortality is negligible, almost all remaining mortality lies *above* the threshold age, so further increases in e_0 no longer automatically equalise lifespans—and adverse shocks at working ages can decouple the two entirely, raising variation while lowering the mean, exactly as the US data for 2015–2021 show.

The American anomaly. The US carries 3–4 more years of lifespan SD than other rich democracies at similar or higher income. Mechanically this reflects elevated mortality at young and middle adult ages—drug overdoses, firearms, motor-vehicle deaths, and cardiometabolic disease—which fattens the left tail of the adult death distribution. Lifespan inequality is thus a compact summary statistic for a feature that e_0 alone obscures: in the United States, the *uncertainty* of one's lifespan is unusually high for a wealthy society.

Limitations. (i) Our deep US history is *white-population* reconstruction; a fuller account would incorporate the markedly worse and separately documented mortality of Black and enslaved Americans, which would *raise* nineteenth-century national variation. (ii) The 1900–1949 US window lacks annual full life tables here because HMD is login-gated and the NCHS/SSA tables are PDF-only; the decennial trend is nonetheless bracketed by Hacker (to 1900) and WPP (from 1950). (iii) WPP figures for data-poor countries are model-smoothed and may understate true variation. (iv) All tables are *period*, not cohort; period lifespan variation answers "how unequal are deaths under this year's mortality regime," which is the policy-relevant quantity but not the experience of any real cohort. (v) We study variation within total populations; an important further axis is the *between-group* component (by income, race, region), which our framework computes but which requires subnational life tables we did not assemble.

7 Conclusion

Life expectancy is a mean, and means hide distributions. When we recover the whole age-at-death distribution and measure its spread, a second great demographic transition comes into view alongside the rise in longevity: the *equalisation* of lifespans. The standard deviation of age at death has roughly halved in the United States since the nineteenth century and fallen by nearly a third worldwide since 1950, as survival curves rectangularised and deaths compressed into old age. That compression was overwhelmingly the work of conquering infant and child mortality, which is why lifespan variation and life expectancy have moved in such tight lockstep—and why, now that the child-mortality dividend is largely spent in rich countries, the two can come apart, as the recent American experience of rising lifespan inequality demonstrates. Measuring the variance, not just the mean, of human lifespans turns "life expectancy" from a single number back into the rich, revealing distribution it always was. All data, code, and figures behind this report are released for reproduction (section B).

A Measure formulas

Let ℓ_0 be the radix, d_x life-table deaths in $[x, x+n)$, $\alpha_x = x + a_x$ the representative age at death, $\eta = e_0$ the mean, and $\bar{e}_x$ remaining life expectancy at the exact age of death (interpolated within the interval). Conditioning on age a replaces ℓ_0 by ℓ_a and restricts sums to $x \geq a$.

$$\text{Variance, SD, CV} \quad \sigma^2 = \tfrac{1}{\ell_0}\textstyle\sum_x d_x(\alpha_x - \eta)^2, \quad \text{SD} = \sigma, \quad \text{CV} = \sigma/\eta.$$

$$\text{IQR} \quad x_{0.25} - x_{0.75}, \quad \text{where } \ell_{x_p}/\ell_0 = p.$$

$$\text{Life disparity, entropy} \quad e^\dagger = \tfrac{1}{\ell_0}\textstyle\sum_x d_x\,\bar{e}_x, \quad H = e^\dagger/\eta.$$

$$\text{Gini} \quad G = \tfrac{1}{2\,\ell_0^2\,\eta}\textstyle\sum_x\sum_y d_x d_y\,|\alpha_x - \alpha_y|.$$

$$\text{Theil} \quad T = \tfrac{1}{\ell_0}\textstyle\sum_x d_x \tfrac{\alpha_x}{\eta}\ln\tfrac{\alpha_x}{\eta}.$$

B Reproducibility

The pipeline is a sequence of small Python scripts in `scripts/`: `lifetable.py` (the measure engine, with self-tests), `01_process_wpp.py` (global panel from WPP), `02_process_us_history.py` and `us_hacker.py` (Hacker reconstruction), `03_build_datasets.py` (derived series), `04_figures.py` (static figures), `05_interactive.py` (Plotly charts), and `06_tables.py` (these tables). Processed datasets are written to `data/processed/`; the master outputs are `wpp_lifespan_measures.csv` (the 123,210-row country-year-sex panel) and `us_master_series.csv` (the 1790–2023 US series). Raw inputs and their licences are recorded in `data/raw/`.

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