Health, Human Capital Development
and the Longevity of Japanese Elites Since 710*

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Abstract
We examine the lifespan of over 40,000 elites in Japan born between 710 and 1912, including samurai warriors, feudal lords, business, political, cultural, and religious leaders at the apex of the social hierarchy. Japanese elites experienced increases in lifespan about 200 years after the European elite, coinciding with the transition to sustained economic growth. After more than a millennium of stagnation, lifespans increased by an unprecedented 2.4 years every decade during the Meiji modernization era, when mortality patterns also became disconnected from weather cycles. College-educated elites benefitted the most, consistent with theories suggesting health improvements are largest as the economy shifts towards a reliance on human capital development. We also find substantial heterogeneity in the longevity returns to a college education, with null effects among women and in occupational categories where access to health knowledge, ascetic lifestyles, or cognitive capacity were prevalent.

Keywords: Longevity, elites, health transition, human capital, Japan

JEL Classifications: I15, J11, N35

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1 Introduction

Links between lifespan, health, and human capital accumulation can shed light on the dynamics of long-run growth because societies should experience increases in life expectancy due to more favorable health conditions, possibly strengthening incentives for acquiring skills as the transition occurs (Bleakley, Costa and Lleras-Muney, 2014; Costa, 2015). An ideal context for testing this hypothesis is where a country experiences a rapid shift from inertia to advancement, coinciding with substantial public investments in education.

Our setting is historical Japan where we examine the changing lifespan of elites using a dataset compiled from more than 40,000 biographies from The Biographical Dictionary of Japan (BDJ). We begin with cohorts born in 710 (the Nara era) and end with those born in 1912 (end of the Meiji era). During this time the country experienced unprecedented changes characterized by the changing dominance of landowning lords, recurring clan warfare, droughts and disease epidemics, and ultimately a transformation from a feudal into an industrial society within just a few decades during the late nineteenth century.

BDJ is a large compendium of individuals who shaped politics, culture, society, and the economy in Japan across more than a millennium, covering those who developed new innovations or founded corporations, those who facilitated the effectiveness of government institutions or played a significant role in shaping cultural norms, values, and beliefs. Foreign born individuals are also included. While focusing on elites entails selection biases towards those who lived long enough to make a mark, the richness of the biographies allows us to quantify shifts in composition and use occupational fixed effects to isolate lifespan changes within broadly similar groups of individuals. We examine longevity conditional on birth cohort, occupation, nationality, gender and education, and control for violent deaths such as execution, assassination, being killed in action, or suicide. Elites exhibit high performance as they contribute to social and economic change, making their study crucial for understanding the mechanisms driving economic growth (Jones and Olken, 2005). The timing of shifts in elite longevity help to delineate the onset of economic development.

Longevity is a fundamental indicator of economic welfare because it acts as a summary measure for changes in well-being (Galor, 2005; Becker, Philipson and Soares, 2005; Acemoglu and Johnson, 2007; Jones and Klenow, 2016). Whether education has a causal effect on longevity is a central topic of interest because it relates to human capital theory and the reasons people choose to invest in skills (Galama, Lleras-Muney and van Kippersluis, 2018; Oster, Shoulson and Dorsey, 2013). Human capital formation is a main component of unified and endogenous theories of growth (Romer, 1990; Galor, 2005) while Costa (2015) argues the relationship between health and education is inherently reciprocal. Our context
allows us to identify differences in longevity by education during the transition from stagnation to growth. The modern education system in Japan institutionalized during the Meiji era, including the spread of compulsory education and prestigious universities, exposed certain cohorts of individuals to greater levels of human capital accumulation compared to others, plausibly varying their incentive to invest in skill acquisition and health.

We identify three primary findings. First, we show a strong relationship between advances in lifespan of elites and economic development. Elite longevity was highly stationary during the millennium between the Nara and Edo eras when the lifespan of elites fluctuated around 60 to 62 years. For elites born during the Meiji era average (unconditional) lifespan jumps by about a decade to 72.5 years, a substantial shift during the onset of sustained economic growth. We show that elites born during the Meiji era gained about 2.44 years of additional life each decade controlling for violent deaths, occupations and demographic characteristics. The timing of increases in longevity in Japan are striking in comparative perspective. De la Croix and Licandro (2015) trace longer lives among famous people around the globe to the cohort born in 1640 to 1649. Cummins (2017) notes two shifts in the longevity of European elites born around 1400 and 1650 when the foundations for modern economic growth were being established (Bouscasse, Nakamura and Steinsson, 2023). Elite lifespans improved in Japan at least 200 years later as the economy experienced better medicine, sanitation, nutrition, and income growth.

Our second finding illustrates that changes in longevity reflected a move away from a Malthusian regime. For cohorts born during the pre-Meiji era, elite mortality coincides with weather cycles, but this relationship dissipates for cohorts born during the Meiji era. Malthus (1798) recognized weather-related factors—the “convulsions of nature”—as population checks whereas growth-induced health improvements and innovation may negate the impact of extreme weather (Deschênes and Greenstone, 2011; Lee and Li, 2021). We utilize death months from biographies showing a higher frequency of deaths during the summer months, when humidity rises affecting the spread of diseases like cholera and dysentery and heat-related illnesses. Individuals who died during those months have a shorter lifespan on average. Pre-Meiji elites who died in July and August, for example, experienced almost a year shorter lifespans than individuals who died in September when using fixed effects for death cohort. The corresponding effect of seasonality during the Meiji era is insignificantly different from zero. We further verify that death month is the driver by showing that birth month has little predictive power for explaining longevity in either the pre-Meiji or Meiji eras, notwithstanding that birth month has been shown to be associated with variation in lifespan in other contexts (Doblhammer and Vaupel, 2001).

Third, we focus on the relationship between education and longevity, examining causal-
ity and sources of heterogeneity. Costa (2015) argues that advancements in health are not a prerequisite for modern economic development but as the economy shifts from emphasizing physical labor (“brawn”) to valuing intellectual skills (“brains”) the returns to investment in human capital are high. This stimulates growth while also promoting the production and absorption of health-related knowledge through a “virtuous circle”. The biographical sketches in BDJ document college-level educational attainment, and the college an individual attended. 53% of the individuals born during the Meiji era had received a higher education compared to 5% born during the Edo era. College educated elites born during the Meiji era lived 2.4 years longer than their counterparts without a college education. This difference was even more pronounced among those who had attended an imperial university, Japan’s leading institutions of higher education. Examining causality is important in light of this finding because individuals may self-select into education based on unobservable characteristics such as personality traits, expected wage returns, or preferences. These factors may be correlated with both occupational choice and health.

Whereas previous literature has used either compulsory schooling legislation or college education to assess the relationship between education and mortality (e.g. Lleras-Muney, 2005; Clark and Royer, 2013; Buckles et al., 2016; Meghir, Palme and Simeonova, 2018; Clark and Cummins, 2020), we use exogenous variation in both. We find no evidence of a major discontinuity in longevity for cohorts affected by an 1886 education reform in Japan, which mandated compulsory secondary education for children aged six and over.

We find more evidence of a college-level effect. We instrument for a college education using a distance-IV in the spirit of Card (1993) and Kane and Rouse (1995) where cost-related mechanisms influence the probability of attendance if individuals choose to relocate from their place of origin. Specifically, we measure distance of a birth prefecture from Tokyo which contained the largest cluster of universities as the Meiji era reforms took effect. The identifying assumption is that the location of one’s birth prefecture is exogenous and that families are unlikely to sort based on this distance. We account for the potential confounding effect of migration by considering both birth and residing prefectures. Following Zhao (2023) we also conduct placebo tests using distances from a random prefecture—Matsuyama, the capital of Ehime Prefecture—showing these distances are uncorrelated with the probability of college attendance, thereby lending support to our identification approach. Instrumented point estimates are close to OLS, implying a 3.0 to 3.2 year lifespan gain from higher education for individuals born during the Meiji era. While we cannot rule out causal effects that are statistically indistinguishable from zero, our evidence is consistent with an important college-education-longevity relationship in this context.

We also highlight heterogenous changes within occupations for individuals born dur-
ing the Meiji era. We find the raw relationship between a college education and longevity is strongly positive in four of our seven occupational categories. However, the effect is statistically indistinguishable from zero in “Government and Politics”, “Religion and Spirituality” and “Scholars and Science”. This implies that the relationship between education and longevity may be moderated by factors such as potential access to health facilities or medical knowledge, ascetic lifestyles, or cognitive capacity. Consistent with findings from the review by Galama, Lleras-Muney and van Kippersluis (2018), we find the longevity returns to a college education were larger for Japanese men than women.

Our analysis attempts to advance our understanding of the changing lifespans of elites in Japan over a 1,200 year period and how these changes relate to economic growth. Prior work has largely focused on elites from various regions around the world, especially Europe (David, Johansson and Pozzi, 2010; De la Croix and Licandro, 2015; Cummins, 2017) and these important studies allow us to benchmark the timing of Japanese lifespan changes in relation to development trajectories and Malthusian dynamics (Galor, 2005). Bassino et al. (2019) note in the context of the Great Divergence that “Japan continued to fall behind until after the institutional reforms of the early Meiji period.” We find improvements in elite longevity coincided markedly with the onset of continuous economic development.

We complement work on elite mobility in Japan over time. Traditional accounts suggest the Meiji era was associated with a departure from rigid social structures and a decline in the importance of the samurai class (e.g. Takane, 1981; Sonoda, 1990). Clark and Ishii (2013), on the other hand, detect persistence in elite formation through the continuity of surnames. Matsumoto and Okazaki (2023) find a middle ground between these findings whereby the Meiji Restoration initially boosted commoner inclusion in elites but over time the composition of elites reverted to previous social hierarchies, reducing meritocracy. While we do not study mobility, our evidence suggests a distinct break during the Meiji era in terms of the lifespans and human capital development of the Japanese elite.

Research on the longevity of economic elites in Asian economies is sparse, so we aim to fill this gap with new data. An exception is Lee and Li (2021) who show that exposure to extreme weather events in childhood shorted the lifespan of Chinese elites, born from 1–1840, spanning the Western Han dynasty to the Qing dynasty. Our estimates show weather cycles mattered only prior to the onset of modern economic growth in Japan, implying health improvements associated with the Meiji Restoration may have facilitated adaptation to climate-induced mortality. Equally, development and trade can lead to the spread of germs as much as improved medical knowledge. In the context of Meiji Japan, Tang (2017) shows that infrastructure improvements—specifically railroads—were a key vector for disease transmission and premature deaths while Ogasawara and Inoue (2018)
show that cholera outbreaks as the country transitioned to growth still stunted adult heights. A limitation of our study is that elites may have been insulated from the most extreme disease environments due to their social standing. A strength is that societal changes often begin with influential individuals and our findings reveal how links between health and human capital development can be identified in the changing lifespan of elites.

We can incorporate human capital development into our analysis because we observe the education of elites systematically using the information in BDJ. A long line of research considers the significance of education as a driver of modern economic progress in theory (Becker, 1962; Nelson and Phelps, 1966; Galor, 2005), and empirical settings associated with industrialization (Becker, Hornung and Woessmann, 2011). Our contribution lies in illustrating how education may have emerged as a mechanism prolonging the lifespan of elites, consistent with the hypothesis in Bleakley, Costa and Lleras-Muney (2014) and Costa (2015) where health transitions associated with investments in human capital increase the longevity returns to those with higher levels of education.

The remainder of the paper is organized as follows. Section II describes the data and provides descriptive statistics. Sections III presents the estimation strategy and main results on changing elite lifespans over time. Section IV explores mechanisms, specifically weather and human capital accumulation. Section V concludes.

2 The Data

2.1 BDJ as a Source and Age Heaping Tests

Our data come from the digital edition of The Biographical Dictionary of Japan (BDJ) which contains over 75,000 biographies spanning from the Asuka era (538-710) to present-day elites. The volume is edited by distinguished scholars from the fields of history (Ueda Masaaki), science and engineering, (Nishizawa Jinichi), art (Hirayama Ikuo), and cultural affairs (Shumon Miura) so the representation is broad, encompassing economic as well as political and social elites. The compilation, according to its editors, goes beyond highlighting the activities and achievements of a select few individuals with efforts to include influential women and foreign nationals as well. We require that the biographies include birth and death years so we can measure the duration of life. Prior to the Nara era (710-794) the data are limited so we start with those born in 710 while ending with those born in the last year of the Meiji era (1868-1912). Hence, our data encompasses deceased individuals. Following Cummins (2017), we limit our dataset to individuals who were 20 or older at the time of their death, resulting in a dataset comprising 40,660 individuals.
We run a battery of tests to determine the accuracy of the birth and death data. A concern in these types of datasets is age-heaping. When a biographer is unaware of an individual’s precise age, they frequently record ages ending in 0 or 5. Furthermore, individuals tend to misreport their age when they have incentives to do so (Budd and Guinnane, 1991), or as a function of cultural norms and practices which may be reflected in the data found in biographies. This bias can be quantified using Whipple’s Index (WI) which captures how far the age distribution diverges from a condition in which ages ending in 0 and 5 are evenly distributed. Each observation in Figure 1 Panel A represents a WI value calculated using 50 year cohorts where the dashed line at WI=100 represents no bias favoring digits 0 and 5. Towards the end of the time series of our data, where most of the observations are concentrated, WI hovers around 100 suggesting the data are fairly to highly accurate based on Census benchmarks for interpreting WI values. Similar results are found when we use birth years (Panel B) or death years (Panel C) to test for potential asymmetries across these reporting ranges. Because values lower than 100, particularly in early years of the data, suggest possible heaping on digits other than 0 and 5 we take the additional step of calculating Myers Index (MI) which incorporates a test of bias towards digits between 0 and 9 with $0 \leq \text{MI} \leq 90$ representing uniformity to complete heaping. Figure 1 Panel D shows MI values closer to 0, especially for individuals born during the Edo and Meiji eras, indicating less heaping, or a more uniform distribution of ages across digits. In all epochs MI is below 10 indicating a relatively low level of age heaping.

2.2 Qualitative Evidence and Data Coding

The data provide a rich portrait of elites in Japan over time, offering insights into their social status, economic activities, and cultural contributions. Our first entry is Nagate Fujiwara (714-771), who held the position of a Japanese court noble and statesman during the Nara era when a centralized government system first emerged, with the capital located in Nara, the administrative center of Nara Prefecture. Around 40% of our entries in the Nara era are court nobles (i.e. members of the aristocratic class) who held positions of influence and authority within the imperial court. By 730 Japan’s population was around 6.1 millions with GDP growing at just 0.15% per year from 730 to 950 (Bassino et al., 2019). Transitioning to the Heian era (794-1185) when the capital moved to Heian-kyō (modern-day Kyoto) art, literature, and culture flourished and BDJ includes an entry for Yukihira Ariwara (818-893) a court nobel and poet. Concurrently, the growing influence of provincial warrior clans marked a shift towards a more decentralized feudal system during the Kamakura era (1185-1333). Indeed, our data include Yoritomo Minamoto (1147-1199) who founded and
served as the inaugural shogun of the Kamakura shogunate.

The Muromachi era (1333-1568) was characterized by the rule of the Ashikaga shogunate (35 members of the Ashikaga family are in BDJ) whose ultimate demise marked the transition to the Azuchi-Momoyama era (1568-1600), a short epoch when influential daimyo like Oda Nobunaga (1534-1582), a feudal lord covered by BDJ, played a pivotal role in establishing foundations for Japan’s subsequent unification under the Tokugawa shogunate and the establishment of the Tokugawa government in the city of Edo (modern-day Tokyo). Japan’s population stood at 17 millions at the start of the Edo era (1600-1868) rising to 34.5 million during the early years of the Meiji Restoration with an urban population share of 10.4% compared to 2% in 730 (Bassino et al., 2019).

Most of our observations (87%) pertain to individuals born during the Edo and Meiji eras where Edo-era economic advances laid the foundation for subsequent growth. We observe the lives of business elites like Takatoshi Mitsui (1622-1694) who founded the Mitsui conglomerate, a large and influential zaibatsu, cultural figures such as Tokuzo Chikamatsu (1751-1810), a kabuki artist from the middle-to-late Edo period, the famous sumo wrestler Gontazaemon Maruyama (1713-1749), Emperor Meiji (1852-1912) whose reign oversaw the Meiji Restoration, as well as social entrepreneur Sutematsu Oyama (1860-1919) who became an advocate for women’s education. Among foreign nationals, BJD lists William Adams (1564-1620), also known as Anjin Miura, an English merchant who arrived in Japan in 1600 on a Dutch East India Company ship.

As demonstrated by these examples, significant compositional changes occur over time in the types of individuals documented in BDJ. This variation reflects the evolving landscape of Japanese development across cohorts born between 710 and 1912. To capture these changes in our empirics, we use a system of keywords to allocate individuals to 7 occupational categories using words such as “daimyo”, “politician”, and “bureaucrat” to define Government and Politics, “monk”, “shinto”, “buddhist”, and “priest” to define Religion and Spirituality, “kabuki”, “playwright” and “sumo” to define Arts, Culture and Sport, “professor”, “scientist”, “engineer”, and “physicist” to define Scholars and Science, “samurai” “commander” and “warrior” to define Warriors and Military, “merchant”, “banker”, “financier” and “inventor” to define Business, Technology and Finance, with a final Miscellaneous category. Since individuals may fall into more than one occupational category we test the stability of our approach by varying the ordering of the keywords. When we reverse the sort order of the keywords, 91% of individuals are assigned to the same occupation, whereas 96% are when the sort order is randomized.

Figure 2 displays the distribution of occupations within each era, represented as percentages. During the earlier eras a larger share of individuals are allocated to the Govern-
ment and Politics category given the importance of the imperial court both politically and culturally, whereas the Warriors and Military category grows from the Heian era in line with the emergence of powerful provincial clans vying for control. For the Meiji and Edo eras, the categories are more symmetrically organized. This is advantageous for our purposes because it means occupational fixed effects are more likely to capture time-invariant characteristics of individuals that may also impact longevity.

We also code mortality event and demographic variables. The biographies detail violent deaths, an important issue given that longevity is our outcome variable and the tumultuous circumstances in which many of these elites lived. We code up a “Violent Death” variable capturing those who died because they were killed in action or executed, assassinated, or committed any form of suicide, including ceremonial disembowelment (seppuku or harikiri) or double suicide where two individuals chose to end their lives together.

We observe the nationality of individuals included in BJD. Foreign-born individuals may experience different health or socioeconomic environments. We code gender given that expectation of life is longer for women than men. Life tables for the general population during the Meiji era, for example, show that for cohorts born 1891 to 1898, life expectancy at birth was 42.8 years for men and 44.3 years for women (a 1.5 year difference). We capture education using college graduate indicators, since the biographies are systematic in their coverage of this attribute including the university an individual attended.

Where available, we extract from the biographies the birth and residing prefectures of each individual to test for spatial variation in elite lifespan. In about two-thirds of the cases birth prefecture is the same as the residing prefecture where we observe both. Figure 3 maps these data showing the largest concentrations of elites in the prefectures of Tokyo, Osaka, and Kyoto, in line with focal places in the distribution of the population.

2.3 Descriptive Statistics

Table 1 summarizes data for each era where individuals are grouped according to their birth year by era. A pattern of stability in unconditional longevity over approximately 809 years between the Nara and Edo eras, followed by an abrupt change during the Meiji era, stands out. While the duration of elite lives fluctuated around 60 years for much of Japan’s history it increased by 18% to 72.5 years for elites born in the Meiji versus the Edo eras. In early data, lifespans roughly match the 60.9 years found by De la Croix and Licandro (2015) for famous individuals up to the 14th century and exceed the range of predicted lifespans found by Cummins (2017) for the European elite. Meiji era elites in BDJ experienced about the same longevity as contemporaneous Cardinals of the Catholic Church, Habsburg
elites (comparisons that De la Croix and Licandro also provide) and members of the British ducal elite after accounting for violent deaths (Hollingsworth, 1957). These comparisons are subject to the caveat that selection biases may vary over time and contexts.

Within Japan, we further illustrate the striking Meiji-era change in Figure 5. Panel A plots Kaplan-Meier survival curves of the probability of surviving for elites in each era. The survival curve for elites born during the Meiji era shifts noticeably to the right, indicating prolonged longevity compared to other eras. Panel B plots the frequency of age at death in the Edo and Meiji eras, revealing a predominant rightward shift. There appears to have been a large reduction in death rates in the Meiji era at younger ages. Anomalies persist across eras in the upper tail—for example, Iida Gizan (1742-1859) a calligrapher from the Edo era who lived to be 117, or Onishi Ryokei (1875-1983), a Buddhist priest from the Meiji era who reached 108 year of age. Nevertheless, there is a noticeable trend towards increased longevity both generally and among specific elite groups. Even Sumo wrestlers born during the Edo era lived to be around 54.7 years of age on average whereas they lived to be 59.0 on average if they were born during the Meiji era.

The data on longevity are equally striking within era. Figure 6 presents binscatter plots of lifespan against year born showing no evidence of secular improvements in longevity within each era from Nara to Edo. By contrast, the linear relationship is strongly positive during the Meiji era implying general societal or scientific advancements. Given the abruptness of the Meiji Restoration and the initially low baseline of health provision, advances in incomes, education, sanitation, medicine and targeted efforts at disease control would have led to significant gains. In Tokyo, for example, there were 37 hospitals in 1887 compared to 159 in 1917, just after the Meiji era had ended. During the same time period the number of doctors in Tokyo more than doubled from 2,565 to 5,488. Advances often occurred as policy measures to mitigate health risks. In 1879, the government directed all prefectures to establish Health Bureaus as part of the modernization program because the promotion of domestic and international trade had opened up the country to disease spread (Tang, 2017; Ogasawara and Inoue, 2018). Official statistics from 1882 show that epidemics were still the main cause of death, followed by gastrointestinal and neurological diseases.

Of the remaining variables in Table 1, violent deaths account for a reasonably low share of deaths over time, as expected, given individuals who died early had less time to make a sufficient enough impact to be included in BDJ—the left truncation problem associated with all studies of elites noted by De la Croix and Licandro (2015). Cummins (2017) finds that prior to the middle of the sixteenth century about 30% of European aristocrats and nobles died in battle compared to under 5% thereafter. The share of violent deaths among Japanese elites is highest at 9% in the Muromachi era, which was marked by significant
political upheaval, violence and internal conflict. The share “Killed in Action”—a component indicator of violent deaths—during this era is 3.8%, compared to the next largest share of 1.9% occurring during the turbulent Azuchi-Momoyama era.

Japanese nationals account for most of the data since BDJ focuses on achievements within Japan. During the Edo and Meiji eras where we have sufficient observations to calculate reliable means, the average lifespan of the non-Japanese is 66.68 (n=730) and 72.52 (n=497) years respectively compared to 61.19 and 72.48 years for Japanese citizens, implying a narrowing to elimination of differences in longevity between these two groups, although we caution that selection biases may also have changed. Some Japanese elites spent time abroad, potentially complicating our ability to directly attribute their longevity to changing health circumstances in Japan. Suga Atsuko (1929-1998), for example, a prestigious translator and scholar of Italian literature studied in Paris before she moved to Milan in the late 1950s. The share of women in the dataset fluctuates between 4% and 10% over eras. Unconditional mean lifespan for Japanese women in our data is 2.7 years longer than for Japanese men during the Edo era and 2.1 years longer in the Meiji era.

Finally, we note a dramatic change in the education of Japanese elites over time, consistent with Meiji-era modernization policies focusing on educational attainment and universal literacy. While the intended spread of education did not always coincide with commensurate resource allocation among the general population (Taira, 1971), and during the early years of the Meiji Restoration decedents of samurai families accounted for most graduates, we find that 53% of elites born during this era had received a college education. Although institutions of higher education existed during the Edo era (7 universities were founded between 1580 and 1863, all in Tokyo or Kyoto) diffusion occurred extensively during the Meiji era, with 70 universities being founded between 1871 and 1911 including the imperial universities in Tokyo (1877), Kyoto (1877), Tohoku (1907), and Kyushu (1911) with Hokkaido Imperial University being established in 1918. In Figure 4 we show that among individuals who did receive a higher education, the overwhelming majority (63.8%) had attended Tokyo Imperial University. Within the group of leading private universities, most elites (9.4%) had been educated at Waseda University, founded in 1882.

Education and health are mutually reinforcing. Among other mechanisms, widening longevity differentials may emerge because individuals invest in their own well-being. Increased levels of health, in turn, facilitate the acquisition of more knowledge (Grossman, 1972; Heckman, 2007; Costa, 2015). During industrialization, innovation can increase the demand for human capital formation as a result of changing occupations and skill requirements (Galor and Moav, 2006; Bleakley, Costa and Lleras-Muney, 2014). In Europe, the relationship between education and economic growth has been established, with the
advancement of “upper tail knowledge” driving innovation and progress (Mokyr, 2002; Squicciarini and Voigtländer, 2015). Unconditional mean lifespan for college educated Japanese elites in our data who were born during the Meiji era is 74.1 years compared to 70.6 years for the non-college educated (a 3.5 year difference). Those who attended an imperial university lived longest at 74.8 years. Later in the paper we estimate this education gradient conditioning on observables while also attempting to test for causality.

3 Estimating Variation in Elite Longevity

3.1 Lifespans Changes Across Eras

Conceptually, variation in elite lifespans over time is different from variation in life expectancy since we do not know the population at risk of becoming an elite. As a general rule De la Croix and Licandro (2015) argue, longevity tends to exceed life expectancy because sample selection bias suggests a tendency towards selection on success, although the two measures are directionally similar when tested empirically. Understanding factors influencing lifespan variation requires comparing “otherwise equivalent” individuals, a particular challenge in our dataset since it covers individuals born over more than a thousand years. Accordingly, we begin by estimating the following regressions:

$$\text{Longevity}_i = \alpha + \sum_{j=2}^{7} \beta_j \text{Era}_j + \delta_1 \text{B}_i + \delta_2 \text{B}_i^2 + \phi \text{V}_i + \gamma \text{D}_i + \eta \text{Occ} + \epsilon_i,$$

(1)

where we capture era cohorts, birth year trends (B), violent deaths (V) as well as demographic controls (D) and occupational fixed effects (η). We examine longevity both using OLS and as a time-to-event variable using Cox proportional hazards models.

Specifically, Equation 1 estimates longevity for individual i measured as death year minus birth year as a function of a full set of era indicators where individuals born during the Nara era represent the baseline omitted category. We index eras sequentially so $H_0 : \beta_7 - \beta_1 = 0$ is a test of whether the difference in lifespan between Meiji era and Nara era elites is significantly different from zero, conditional on observables. Since elites from adjacent eras are more likely to be otherwise equivalent we also estimate $H_0 : \beta_7 - \beta_6 = 0$ as a test of lifespan differences between Meiji era and Edo era elites. While the era indicators capture the average effect of being born in a particular era on longevity, the birth year trends (linear and quadratic terms) capture the trend in longevity over birth years, irrespective of the era. We control for violent deaths whereas our demographic controls include indicators for nationality, gender, and a college education. We use occupation fixed
effects based on the groups illustrated in Figure 2.

Results are reported in Table 2. In column 1, we present coefficients from a basic specification where longevity is modeled as a function of era indicators and flexible time trends in birth years to reflect the changing relationship between birth year and longevity by era shown in Figure 6. Elites born during the Heian era lived around 3.6 years longer than those in the Nara era, those born in the Kamakura era about 4.9 years longer, and elites born in the Muromachi era about 6.1 years longer. We cannot reject the hypothesis that elite lifespans were equivalent to baseline lifespans during the volatile Azuchi-Momoyama era, or during the Edo era. Meiji era elites, however, lived a substantial 13.9 years longer than their Nara-era counterparts, while they lived about a decade longer than elites born during the adjacent Edo era ($\beta_7 - \beta_6 > 0$ as denoted in the base of the table).

When we control for violent deaths in column 2 our estimates remain reasonably stable and the lifespan difference between Meiji and Edo era elites is estimated to be 8.7 years. Columns 3 and 4 add demographic controls and occupation fixed effects in sequence and the longevity gap between Meiji and Edo era elites is around 7 years. In column 4 we find Japanese elites lived shorter lives by about 1.4 years on average over time than foreign born elites, while women lived longer than men and the college educated longer than the non-college educated—by 1.8 years and 3.4 years respectively. Reporting the coefficients on the occupation fixed effects, we find that religious and spiritual elites and those engaged in business, technology and finance lived longest while individuals with political, administrative or military authority lived shortest. We return to the issue of heterogeneity in survival probabilities by occupation later in the paper (see Section 4.2.3).

In column 5, we employ the same specification as in column 4 but limit the dataset to individuals born during the Edo and Meiji eras. This is where we have most observations (see Table 1) and the adjacency of these eras provides the most informative insights into variation in the longevity of elites over time. The coefficients on the demographic controls and the occupation fixed effects remain stable when compared to the estimates in column 4 for all eras. But the magnitude of the longevity gap between Meiji and Edo era elites is now smaller at 3.4 years. This specification includes flexible birth year controls, which absorb the secular increase in lifespan for the Meiji era, shown in Figure 6, Panel G.

To gain a sense of magnitudes, in an additional lifespan regression for the Meiji era only with violent death and demographic controls and occupation fixed effects included, the coefficient on a linear term in birth year is 0.243 (s.e. 0.018), implying the lifespan of the elite population was extended by 2.43 years per decade, an unprecedented rate of change. As an approximate benchmark, average life expectancy for a 20 year old Japanese male increased by around 0.63 years per decade during the late Meiji era.
Returning to Table 2, columns 6 and 7 replicate the OLS regressions in columns 4 and 5 using Cox proportional hazards models. Whereas the OLS results exploit variation in the conditional mean of longevity across individuals born in given eras, the Cox model estimates hazard ratios that represent the relative risk of death occurring at any point in the life cycle for individuals with different covariate values. A ratio less than unity indicates a longer time to death, controlling flexibly for birth year and violent deaths.

Results in column 6 show that individuals faced no significant change in the hazard of death over a lifetime in the Heian to the Edo eras compared to individuals born during the Nara era (the omitted era). In contrast, individuals born during the Meiji era experienced a mortality event over the life cycle at a rate that is 0.629 times lower than that of individuals born during the Nara era whereas column 7 shows a rate that is 0.695 times lower than that of individuals born during the Edo era. These conditional effects are particularly large, showing consistency with the unconditional survival rates depicted in Figure 5, Panel A. In line with our OLS results, the hazard ratios in columns 6 and 7 imply Japanese individuals faced a higher hazard of death relative to the foreign born in Japan, whereas the hazard was lower for women and the college educated relative to their baseline groups.

3.2 Cohort Fixed Effects and Spatial Variation

We now turn to estimation using cohort fixed effects, which help to address unobserved differences between groups of individuals that may influence longevity, such as shared social and economic conditions, or cohort-specific characteristics. We use 10-year cohorts by birth year to estimate changes in lifespan relative to the baseline cohort, conditioning on violent deaths, demographic controls and occupation fixed effects.

Figure 7 presents the results. Panel A plots the coefficients and 95% confidence intervals on the cohort indicators where the baseline cohort is individuals born during the 1850s—immediately prior to the cohort covering the Meiji era. Our sample sizes are much larger from the Edo era onwards, resulting in smaller standard errors, ceteris paribus. While the point estimates fluctuate around zero over most of the time period, the increase in longevity for cohorts covering the Meiji era are much larger. Averaging over the cohort indicators we find an increase in elite longevity over the Meiji era of 5.31 years relative to the baseline, with a 95% confidence interval between 4.58 and 6.01 years.

Using these estimates we can gain granular insights into when these changes in elite lifespans occurred. We estimate 6 coefficients for the Meiji era in Panel A, allowing us to determine the difference in longevity between consecutive 10-year cohorts. The difference between the coefficient for the 1860s and the coefficient for the 1850s tells us the change
in longevity for elites born over that period. We estimate this difference to be -0.392 (s.e. 0.412) and statistically insignificant from zero, suggesting the timing of lifespan increases coincides with the early years of the Meiji Restoration when, for example, government policies targeted cholera, dysentery, typhoid fever, smallpox, diphtheria, and typhus to address their social and economic impact (Tang, 2017). The difference in lifespan for individuals born in the 1870s relative to the 1860s is 1.41 years (s.e. 0.537); for those born in the 1880s relative to the 1870s it is 4.38 years (s.e. 0.744); and the difference for individuals born in the 1890s relative to 1880s is 2.54 years (s.e. 0.664). We estimate a plateauing of the longevity effect based on lifespan differentials between the 1900s and 1890s (0.639, s.e. 0.447) and the 1910s and 1900s (0.719, s.e. 0.544). This suggests policy changes may have resulted in diminishing returns to longevity as lifespans reached biological limits for the time during the Meiji era and into the Taisho and Showa eras.

Panel B plots the coefficients and 95% confidence intervals on the cohort indicators for the Edo and Meiji eras only, again using the cohort born during the 1850s as our baseline. We illustrate the dramatic increase in the lifespan of elites born during the Meiji era, especially from the 1870s, followed by diminishing gains towards the end of the era.

Finally, we show that the increase in elite longevity during the Meiji era was generalized across prefectures. We estimate individual-level longevity regressions using a full set of prefecture indicators for birth or residing prefectures for which these data are available in BDJ. Point estimates and 95% confidence intervals for lifespan changes relative to elites born or residing in Hokkaido Prefecture (the baseline) are shown in Figure 8. These results are indicative of a widespread health transition across geographic locations including more rural and urban prefectures. Socioeconomic development would have varied considerably across geographies due to variation in market access or the depth of financial markets so the findings imply that dissemination of health knowledge occurred independently of the knowledge required for economic growth. Of the three estimates where the lifespan differences are significantly different from zero, Fukui and Gifu prefectures appear to show idiosyncratic trends. Okinawa Prefecture, incorporated into Japan in the 1870s, has exhibited unusual longevity since the early 1900s (Matsushita, 1906).

4 Exploring Mechanisms

4.1 Weather Cycles

Why did elite lifespans increase by so much during the Meiji era? While the range of potential mechanisms contributing to increased longevity is extensive, weather cycles re-
resent a significant factor affecting Malthusian fluctuations. Climate can have a first order effect on longevity as an input that sustains human life (Deschênes and Greenstone, 2011) and a second order effect through floods and droughts which, in turn, influence irrigation, food production and therefore the likelihood of societal unrest (Chaney, 2013).

These impacts may be significant in Japan due to the frequency of extreme weather events such as excess snowfall, typhoons, and dry spells which affected agricultural productivity (Mikami, 2023). Rice production, for example, is highly sensitive to weather conditions throughout the growing season. Prior to the middle of the nineteenth century, Lee and Li (2021) show that encountering three childhood drought years reduced the lifespan of Chinese elites by about two years. Equally, as development progresses, adaptation is expected to weaken the correlation between weather and lifespan.

There are at least four challenges associated with measuring the relationship between weather cycles and longevity in our context. First, weather data in Japanese historical records are limited. Mikami (2023) describes an ingenious method of reconstructing weather data from diaries in the Edo era since each clan kept a logbook, in which the daily weather was recorded. However, our data stretch back to the Nara era where such data are unavailable. Nakatsuka et al. (2020) reconstruct long run weather data from annual tree rings beginning in 600 BC, but this method is prone to capturing mainly summer variation. Other long run series, such as the millennia-spanning cherry blossom records in Kyoto and even older pollen production records in central Japan are also season-specific. Second, linking temperature changes to the location of an individual can be challenging due to the scarcity of location-specific data. Third, Mikami (2023) notes, the correlation of weather fluctuations by region is quite high, which leaves us with little identifying variation. Finally, we face the challenge of measuring when in the life cycle the weather event occurs and linking this to changes in longevity. Lee and Li (2021) rely on exposure during critical early periods of life, but this approach presents difficulties for Japan. Evidence (albeit for a later period) suggests that Japanese children had the capacity to rebound from early-life health shocks (Schneider and Ogasawara, 2018; Schneider, Ogasawara and Cole, 2021).

We are able to overcome these challenges because the BDJ dataset includes not only the year of an individual’s death but also the month. Both the Gregorian calendar (officially adopted in Japan in 1873) and the lunisolar calendar (which had been introduced from China in 690), are organized into 12 months, so if biographies record month of death based on historical documentation of when deaths occurred, we know the periodization will be consistent over time. Thus, we can test systematically for a link between death months and implied weather cycles over the long run while controlling for time-specific influences on either births or deaths using fixed effects. Specifically, we can compare the death months
of individuals who were born in the same cohort, and we can compare the death months of
dividuals who died at the same time, thus ruling out confounding effects like wars.

We begin with descriptive evidence on the frequency of death months, highlighting
differences during the Meiji Restoration. If deaths occurred randomly, each month would
have an equal probability of $\frac{1}{12}$ (or approximately 8.33%), but we would not expect deaths
to be distributed uniformly due to factors like seasonal illnesses or extreme weather events.

Figure 9 Panel A reveals strong trends in the data. In particular, the frequency of deaths
in the summer months is much higher during the pre-Meiji era. For example, 15.6% more
individuals died in the month of July in the pre-Meiji era compared to the Meiji era whereas
15.0% more individuals died in the month of August. Adding more structure to the anal-
ysis, Panel B reports average marginal effects from a Multinomial Logit model where the
dependent variable is a set of discrete categories for death month and the main independent
variable is an indicator for era (coded 1 for individuals born during the pre-Meiji era and 0
for individuals born during the Meiji era). The summer peak is distinctive. The probability
of dying in August, for example, is 1.5 percentage points higher during the pre-Meiji era.

We note that Cummins (2017) finds evidence for a disappearance of a summer peak in
the frequency of deaths over time among the European elite. Our key insight is to show that
individuals who died during the summer months also lived shorter lives on average but only
during the pre-Meiji era. In Figure 10 we plot three sets of point estimates and 95% con-
fidence intervals from death month indicators in regressions where the dependent variable
is lifespan. In the left column we control for violent deaths, demographic characteristics
and occupations, the middle column adds birth cohort fixed effects and the right column
adds death cohort fixed effects. Hence, we are identifying the middle and right estimates
off individuals exposed to the same circumstances at birth or at death, respectively. We find
a strong U-shape in lifespan variation over the year when pooling the data for the pre-Meiji
era (Panel A) and when estimating on individuals born during the Edo era only (Panel B).
In Panel C, by contrast, the estimates are much flatter. In terms of quantitative magnitudes
we estimate a longevity penalty to elites dying in July or August relative to those dying in
September of 0.89 years (p=0.027) in the pre-Meiji era (right column of Panel A), or 0.75
years (p=0.088) in the Edo era (right column of Panel B). During the Meiji era the effect is
insignificantly different from zero at 0.182 years (p=0.591) (right column of Panel C).

We repeat the exercise using birth months as shown in Figure 11 finding an absence of
strong seasonal fluctuations over time. This is not a placebo exercise since a relationship
between birth month and longevity has been documented in the literature. However, the

\footnote{Doblhammer and Vaupel (2001) find that birth month does predict longevity as a result of weather-related changes in health during pregnancy or shortly after birth. In their sample of individuals born during the early}
patterns in Figure 11 stand in stark contrast to what we find for death months in Figure 10. Our results also make sense in the historical context where seasonal diseases like cholera and dysentery were strongly impacted by variation in temperature, rainfall, and sanitation practices. An important component of Meiji era health policies involved investments in waterways, while health and nutrition advances occurred widely.

### 4.2 Human Capital Accumulation

If weather became less important as a determinant of changing lifespans, this implies the emergence of other factors prolonging life as the economy transitioned from stagnation to growth. Our evidence suggests human capital accumulation played an increasingly important role, where education, in turn, can amplify responses to the availability of new health knowledge and increase the willingness of individuals to invest in new skills. Table 1 shows a high rate of educational attainment among elites during the Meiji era while Table 2 shows increased longevity among college-educated elites. We now investigate this mechanism further, attempting to also establish if the relationship is causal.

Our analysis is based on the institutional details associated with the development of the Japanese education system, which involved a commitment to literacy through compulsory education. The 1872 education system (under the Education System Order) established a hierarchical structure with university districts, secondary school districts, and elementary schools. The increase in secondary and higher education corresponded with a rise in literacy rates. By the end of the Edo era the literacy rate was approximately 35% for adult males and 8% for adult females, reaching at least 70% for males and 60% for females by end of the Meiji era (Taira, 1971). The imperial universities were tasked with educating the elite and disseminating Western scientific knowledge while a growing network of private universities focused on specialized training and applied skills. Figure 4 shows that a particularly large share of Japanese elites were educated at these institutions.

The mechanisms through which education can influence longevity are varied, encompassing direct dissemination of new knowledge regarding health and health-related behaviors, and indirect benefits through the labor market (Clark and Royer, 2013). According to human capital theory, a prolonged life expectancy boosts the motivation for investing in skill development, while a virtuous cycle means good health leads to better health outcomes, especially in environments where the returns to intellectual capital become relatively more important (Costa, 2015). Equally, education can be associated with adverse conditions in the twentieth century, those born in the northern hemisphere lived longer if they were born in the fourth quarter rather than the second quarter and vice versa for those born in the southern hemisphere.
health habits such as smoking and excess alcohol consumption. Because reduced form evidence will subsume all of these mechanisms, the overall effect of health on longevity is indeterminant. Additionally, as Clark and Royer highlight, these effects may manifest differently across the educational life cycle; for instance, the association between compulsory education and longevity may differ from that of a college education if the wage returns to a college education are higher. In our data we can assess this relationship at both stages.

4.2.1 Compulsory Education Legislation

We first exploit changes in compulsory education as a consequence of an 1886 law, which required all children six years and over to attend three years of school. In 1900, this period was extended to four years, and further prolonged to six years in 1908 before the nine-year compulsory education system was established in 1947. We compare the lifespan of elite individuals from cohorts before and after the 1886 shift in compulsory schooling reforms occurred. No evidence suggests other abrupt changes in unobservables occurred during the year when the laws were amended, which could confound our analysis.

The empirical literature employs compulsory education reforms to analyze the causal relationship between education and health outcomes. While some studies find positive effects (Lleras-Muney, 2005) others, including our own, report effects that are insignificantly different from zero (Clark and Royer, 2013; Meghir, Palme and Simeonova, 2018; Clark and Cummins, 2020). We do not find evidence of a sharp discontinuity in the lifespan of elites at the threshold associated with changes in compulsory schooling laws.

Figure 12 provides our evidence. Panel A shows a somewhat discontinuous relationship between education and elite lifespan using a linear function, but the apparent discontinuity disappears when using a higher-order polynomial to fit the data. These plots utilize observations for all Japanese elites born during the Meiji era. In Panel B, we restrict the sample to only men as school completion rates for women lagged behind, but again we find no evidence of a discontinuity in lifespan by cohorts exposed to compulsory secondary education laws. In Panel C we restrict the sample to only men who were born in Tokyo because other areas of the country may have lagged behind due to constraints on public resources. Our graphical evidence does not support an effect of the new policy. One explanation for this null result is the secular increase in literacy rates going back to the Edo era muted the impact of Meiji era education reforms. Taira (1971) estimates that literacy rates would have been about the same had the reforms not taken place, specifically due to the continuation of pre-existing trends. Another explanation is that the channel through which education affects longevity occurs at a more advanced stage, and we turn to that analysis next.
4.2.2 Instrumenting for College Attendance

The main difficulty associated with identifying whether there are lifespan returns to a college education is ability bias, where individuals with higher abilities tend to invest in their well-being through educational attainment and health. We use an instrument for college education akin to the distance-IVs used to identify the wage-returns to education (Card, 1993; Kane and Rouse, 1995). The main idea is that distance should increase the cost of accessing education while being uncorrelated with the outcome variable directly. A potential issue is that wealthier parents sort into locations, meaning childhood circumstances as a function of distance may jointly influence the probability of going to college and outcomes (Carneiro and Heckman, 2002). In our context, mobility was more limited meaning parents were less likely to sort into locations based on the educational opportunities available. Furthermore, our evidence in Figure 8 illustrates little variation in longevity by birth or residing prefecture, supporting our assumption that the impact of distance on educational access is not capturing differences in nurturing environments.

Because we know the birth prefecture and the residing prefecture of elites in our data we can calculate distances from the capital cities of each prefecture to Tokyo where the main cluster of universities were located. Between 1868 and 1912, 70 universities were founded, 41 (58.6%) of which were located in Tokyo. Tokyo Imperial University was a symbol of prestige and social status. However, distance imposed differential costs on attendance. In 1877, its founding year, annual tuition was 12 yen, or about two months’ wages for an agricultural laborer. Travel costs were high relative to average incomes and almost 90% of students received a monthly stipend of 4 to 5 yen to offset their expenses (Kaneko, 1987). Imperial universities were ultimately spread throughout the country precisely because distance impeded attendance. The cost of tuition at private schools was typically comparable to or lower than that of public universities. For example, in 1882 the tuition fee at Waseda University, located in Shinjuku, Tokyo, was also 12 yen per year.

Our identifying assumption is that proximity to Tokyo affects the probability of college attendance, without directly impacting lifespan except through this channel, including any income effect on longevity that might arise after graduation. Mean distance to Tokyo in the data is 221 miles. Zhao (2023) cautions that distance-IVs can potentially identify spurious spatial correlations that violate the exclusion restriction, and suggests using placebo distances to ensure robustness. Hence, we also report instrumental variable estimates where we use distance to a random prefecture—Matsuyama, the administrative center of Ehime Prefecture. Mean distance to Matsuyama in the data is 295 miles. This distance should not matter to the probability of an individual receiving a college education.

We first present OLS and Cox proportional hazards results in Table 3 covering both
the Edo and Meiji eras and the full set of data irrespective of whether birth or residing
prefectures are observed. We then focus on the Meiji era for identification, as this is where
we observe a higher frequency of college attendance (see Table 1). When we pool the
Edo and Meiji eras together (Panel A) college educated elites lived around 3.4 years longer
compared to their counterparts without a college education in our baseline specification
(column 1) or 2.9 years longer in our most stringent specification in column 4 with a full
array of controls and fixed effects. Their hazard of death is estimated to be about 11.7%
lower in column 5. In Panel B, where we just use individuals born during the Meiji era, the
college longevity effect is 2.4 years in column 4 with a hazard of death that is about 10.4%
lower. These estimates suggest a narrowing of lifespan differences by education over time,
possibly due to general public health interventions during the Meiji Restoration.

Focusing on the Meiji era, we know the institutions of higher education that each indi-
vidual attended, so we can describe the relationship between longevity and the quality of
education. We present these findings graphically. Figure 13 shows results from regressions
on indicators for different types of colleges relative to a baseline of no college attendance.
We estimate with and without occupation fixed effects, so we mimic the specifications in
columns 3 and 4 of Table 3. Without occupation fixed effects our OLS estimates show
that attending any college is associated with a 2.6 year gain in longevity over the non-
college educated, a private university with a 2.8 year gain and an imperial university with
a 3.8 year gain. With occupation fixed effects, these estimates change to 2.5, 1.7 and 2.5
years respectively suggesting individuals with different levels of education sort into differ-
ent occupations based on unobserved characteristics that also affect longevity. In our Cox
estimates we find similar patterns, though the hazard of death at any point in the life cycle
is always lower for individuals who had attended an imperial university. Across both sets
of estimates we find systematic evidence that the college educated lived longer.

Table 4 presents our IV results where we assess whether this relationship is causal.
Panel A includes all observations where we have information on an individual’s birth pre-
fecture, while Panel B estimates are based on a sample where birth prefecture and residing
prefecture match. Recall that we need this information in order to calculate our distance-IV.
We exclude foreign born individuals, violent deaths and restrict the sample to individuals
born after compulsory secondary education was introduced. OLS results in column 1 show
college educated elites lived approximately 2.7 years longer than non-college educated
elites. This is about in line with our estimates from Table 3 Panel B, column 4.

Our first-stage estimates show that as the log distance from Tokyo increases, the prob-
ability of attending college decreases. In Panel B column 3 the baseline probability of
attendance is 0.48, so the probability would decrease by 7.1% for an individual born and
residing in Chiba prefecture (adjacent to Tokyo) compared to 26.8% for an individual born and residing in Hyogo prefecture (about 270 miles to the west). While the Montiel-Pflueger effective F-statistics indicate weak instruments in Panel A, maximal bias is under 5% in Panel B (Olea and Pflueger, 2013). As such, the instrument exhibits greater explanatory power for individuals with a stable geographic location. In column 5 we add interactions between the instrument and an indicator for women as well as interactions between the instrument and each of the occupation dummies. This strengthens the validity of the identification strategy if distance to Tokyo affects the likelihood of college attendance differently for men and women or for those with latent personality traits that influence subsequent occupation choices. The downside of this approach is weaker instruments. We find a weaker first stage in Panel A, column 5 although maximal bias remains under 10% in Panel B. The effective F-statistics on the placebo excluded instrument in column 7—where distance to a random city is measured instead—are both small, providing support for the validity of the distance to Tokyo instrument used in the first stages in columns 3 and 5.

Our instrumented estimates imply large but variable casual effects of education on longevity while the placebo exercise returns null results, as expected. In column 2 we estimate an effect of college education on elite lifespan of 3.0 years in Panel A or 3.2 years in Panel B. While similar to our OLS estimates in column 1, the 95% confidence intervals include negative values, spanning -1.64 years to 8.11 years in column 2 of Panel B where the effective F-statistic is largest. In column 4 Panel B we find the most precise college-education estimate of 3.0 years with a 95% confidence interval between -0.60 years and 6.57 years. Consistent with much of the literature attempting to identify the relationship between education and longevity reviewed by Galama, Lleras-Muney and van Kippersluis (2018), IV estimates can have imprecision given the potential for complex confounders associated with longevity to increase standard errors. In our data, we cannot rule out, for example, that non-monetary social capital in families changed systematically with proximity to Tokyo, influencing both access to high quality education and health resources. What we can say, based on our evidence, is that the results are strongly suggestive of lifespan returns to education, and with an effect at the college rather than the schooling level.

### 4.2.3 Heterogeneity by Occupation and Gender

As a final step in our analysis of Japanese elites, we highlight these complex channels by illustrating variation in the lifespan returns to education by gender and occupation. All of our estimates so far have relied on average effects across ages, whereas we now turn to conditional estimates of the relationship across different stages of the lifespan.

We estimate linear probability models of survival to age $x$ using Equation 2 based on
a method used in Clark and Royer (2013). We construct an age-year panel for individuals born during the Meiji era, with 86 observations for each individual, covering ages 20 to 105 inclusively. For each individual $i$, we assign a code of 1 if they survive to age $x$ and 0 if they do not. If elites with a college education exhibit systematically prolonged longevity, we expect the graph of the $\lambda$’s to be an inverted-U shape over the life cycle, starting at 0 at age 20 when individuals enter the dataset and ending at 0 at 105 when most had exited through death. The probability of survival, conditional on education, birth year ($B$), violent deaths ($V$) and demographic characteristics ($D$), as well as occupational fixed effects ($\eta$), should be positive in-between.

$$\text{Survival}_i = \alpha + \lambda \text{College}_i + \delta_1 B_i + \delta_2 B_i^2 + \phi V_i + \gamma D_i + \eta \text{Occ} + \epsilon_i$$ (2)

Figure 14 Panel A plots the $\lambda$’s for all Meiji-era elites, showing a higher probability of the college educated surviving at every age on the x-axis relative to the non-college educated, with the effect only diminishing for individuals in very upper ages where idiosyncratic factors may play a more significant role in predicting exceptional longevity. Panels B and C reveal notable disparities in the relationship between a college education and lifespan between genders, with the effect being more pronounced among men than women. College educated men have higher survival probabilities relative to non-college educated men across ages, but for women the survival probabilities are almost always insignificantly different from zero. This difference may be driven by occupational selection, biology and genetics, diet or hygiene standards that may be more symmetric among women by education level. It could also be an artifact of the smaller sample size.

Figure 15 plots the $\lambda$’s for each of our occupational categories (thus dropping the occupation fixed effect from Equation 2) where we find important sources of variation in the relationship between a college education and longevity. In three categories—“Government and Politics” (Panel C) “Religion and Spirituality” (Panel D) and “Scholars and Science” (Panel E)—we find weak to no evidence that the probability of survival to a given age was different as a function of college attendance. If the relationship between education and lifespan is determined by access to health resources, behaviours and knowledge, as economists often postulate, the health consequences of education may have a more limited effect in these categories in this context. Japanese political elites had access to health facilities and knowledge, as well as stable incomes. Given their commitment to asceticism, religious elites may have considered formal education inconsequential to their spiritual pursuits. Scholars and scientists (Panel E), may have an inherent cognitive capacity to assimilate health-related knowledge irrespective of educational attainment.

In the remaining four occupational categories, which account for 57% of our data, we
find stronger evidence supporting a relationship between education and longevity. For elites who made their contributions in arts, culture and sport (Panel A) education is associated with positive survival probabilities across all age ranges. In military occupations (Panel B) survival probabilities conditional on a college education are especially high in younger ages, which makes sense as education was a prerequisite for ascendency in the hierarchy, thereby reducing the likelihood of participation in active conflict. The Japanese Imperial Military Academy, for example, engaged in rigorous selection to prioritize military science and training for career officers. By contrast, among those engaged in business, technology and finance, (Panel F) it is in older age ranges where the effect of a college education is most pronounced. In miscellaneous occupations (Panel G), we observe a discernible college-effect throughout the range of ages. While our findings suggest college-educated elites generally experienced increased longevity, we also underscore the differential effects of education as Japan underwent its Meiji era health transition and the often multifaceted mechanisms linking elite socioeconomic status with longevity.

5 Conclusion

Longevity and its determinants have been of considerable interest throughout human history, occupying a central place in our understanding of economic development, historical transitions, and the limits to population growth. In *An Essay on the Principle of Population* (1798), Thomas Malthus argued that there is no discernible impact on human lifespan resulting from intellectual pursuits or intelligence; rather mortality was a natural and inevitable aspect of human existence:

[I]n the great diversity of characters that have existed during some thousand years, no decided difference has been observed in the duration of human life from the operation of intellect[;] the mortality of man on earth seems to be as completely established, and exactly upon the same grounds, as any one, the most constant, of the laws of nature.

By the time that Malthus was writing, the European elite had already begun to experience increased longevity, prior to industrialization (Cummins, 2017). The ascent in elite lifespan in Japan occurred about 200 years later in the Meiji era, reflecting a period of delayed modernization, health advancements, and investment in education.

The stability of lifespans among the elite class in Japan from the Nara to the Edo eras is as striking as it is explicable by weather cycles, as is the deviation from seasonal mortality patterns during the Meiji era. Improvements in hygiene, medicine, and nutrition, likely
influenced the changing lifespan of elites in a context where education as a channel may have enhanced the responsiveness to health-related knowledge. When intellectual skills supersede physical capabilities, the returns to human capital are amplified, fostering growth and health-promoting behaviors (Bleakley, Costa and Lleras-Muney, 2014; Costa, 2015). Based on our dataset of elites who defined the course of Japanese history over more than a millennium, longer lifespans coincided with health investments and the economy’s shift towards emphasizing human capital development.
References


Zhao, Qiyi C. 2023. Rethinking “Distance From”: Lessons from Wittenberg and Mainz. MPRA Paper 118414 University Library of Munich, Germany.
**Figure 1: Age Heaping Tests**

[A: Age](#)  
[B: Birth Year](#)  
[C: Death Year](#)  
[D: Age](#)

**Notes:** These figures show age heaping tests. The Whipple Index quantifies the extent to which the age distribution diverges from a condition (denoted by 100 marked by the dashed line) in which there is no bias towards ages ending in 0 and 5. The fitted lines represent a linear fit to the estimates shown. The Myers Index quantifies based on all ten possible digits where a value of 0 represents perfect uniformity and no heaping over digits and 90 indicates that all ages were reported with the same final digit.
**Figure 2: Elite Composition by Occupation**

![Elite Composition by Occupation](image)

Notes: This figure shows the distribution of individuals in the dataset by their occupational categories.

**Figure 3: Geographic Location**

![Geographic Location](image)

Notes: These maps show the distribution of individuals in the dataset according to the prefecture in which they were born and the prefecture in which they resided.
### Table 1: Descriptive Statistics

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</table>

**Notes:** This table shows mean values, with violent deaths (defined as killed in action, executed, suicide, or assassination) Japanese versus foreign, female versus male and college educated versus non-college educated as indicator variables.

### Figure 4: Universities Attended

- **Tokyo Imperial University:** 63.8
- **Kyoto Imperial University:** 11.3
- **Tohoku Imperial University:** 2.7
- **Kyushu Imperial University:** 1.5
- **Hokkaido Imperial University:** 1.4
- **Hitotsubashi University:** 3.3
- **Keio University:** 6.1
- **Waseda University:** 9.4
- **Doshisha University:** 0.4
- **Meiji Gakuin University:** 0.1

**Notes:** This figure shows the percentage of individuals born during the Meiji era who attended select universities conditional on those who received a higher education.
Figure 5: Lifespan Distributions

A: Kaplan-Meier Survival

B: Frequency Distribution

Notes: These figures show the relationship between survival time and era of birth using the Kaplan-Meier method (Panel A) and the frequency of observations by age of death (Panel B).
**Figure 6: Within Era Changes in Longevity**

**Notes:** This figures show binscatter plots of the relationship between lifespan and year of birth.
**Table 2: Factors Influencing Lifespan: Nara to Meiji Era**

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**Notes:** This table reports coefficients from regressions where the dependent variable is lifespan. All variables are indicators. The baseline era in columns 1 to 4 and 6 is Nara. The baseline occupational category is Miscellaneous. Birth year controls include birth year and its square. Standard errors are clustered by birth year. *p<0.1, **p<0.05, ***p<0.01.
Notes: Top panel plots point estimates and 95% confidence intervals from 10-year cohort fixed effects in a regression where the dependent variable is lifespan, controlling for violent deaths, demographic characteristics and occupations. The bottom panel use data for the Edo and Meiji eras only. Standard errors are clustered by birth year.
Figure 8: Spatial Variation in Elite Lifespan During the Meiji Era

Notes: The top and bottom panels use data for the Meiji era only, plotting point estimates and 95% confidence intervals from birth prefecture or residing prefecture fixed effects controlling for birth year and its square, violent deaths, demographic characteristics and occupations. The baseline prefecture is Hokkaido. Standard errors are clustered by birth year.
Figure 9: Weather Cycles and Death Months

Panel A shows the percentage of deaths by month in the pre-Meiji and Meiji eras. Panel B displays multinomial logit estimates of the average marginal effects of the probability of dying in a given month associated with being born in the pre-Meiji era relative to the Meiji era, controlling for violent deaths, demographic characteristics, and occupations.

Notes: These figures show the relationship between weather cycles and death months where Panel A shows the percentage of individuals who died in a given month of the year in the pre-Meiji and Meiji eras and Panel B shows multinomial logit estimates of average marginal effects of the probability of dying in a given month associated with being born in the pre-Meiji era relative to the Meiji era, controlling for violent deaths, demographic characteristics, and occupations.
FIGURE 10: DEATH MONTHS: WEATHER CYCLES AND LIFESPAN

Notes: These figures plot point estimates and 95% confidence intervals from death month fixed effects in regressions where the dependent variable is lifespan, controlling for violent deaths, demographic characteristics and occupations. The second and third columns control additionally for birth cohort and death cohort fixed effects respectively. The baseline month is September. Standard errors are clustered by birth year.
Figure 11: Birth Months: Weather Cycles and Lifespan

Notes: These figures plot point estimates and 95% confidence intervals from birth month fixed effects in regressions where the dependent variable is lifespan, controlling for violent deaths, demographic characteristics and occupations. The second and third columns control additionally for birth cohort and death cohort fixed effects respectively. The baseline month is September. Standard errors are clustered by birth year.
**Figure 12: Lifespan and Education: Reform Discontinuity**

![Graphs showing lifespan changes around a threshold denoted by the 1886 education reform in Japan.](image)

### A: All Individuals

### B: Men Only

### C: Men Born in Tokyo

**Notes:** These figures show how lifespan changes around a threshold denoted by the 1886 education reform in Japan which mandated compulsory education for children aged 6 and over. The threshold is set for cohorts born in 1881. The panels on the left use a polynomial of order 1 to model the relationship and the panels on the right polynomials of order 3. Formal estimates fail to reject the null hypothesis of no discontinuity at this threshold.
**Table 3: Lifespan and Education**

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<td>2.989***</td>
<td>3.215***</td>
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<td>(0.260)</td>
<td>(0.253)</td>
<td>(0.257)</td>
<td>(0.014)</td>
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<td><strong>Panel B: Meiji Era</strong></td>
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**Notes:** This table reports coefficients from regressions where the dependent variable is lifespan. All variables are indicators. Standard errors are clustered by birth year. *p<0.1, **p<0.05, ***p<0.01.

**Figure 13: Lifespan and College Quality**

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**Notes:** These figures plot point estimates and 95% confidence intervals from regressions where the dependent variable is lifespan. All variables are indicators, so the coefficients show the change in lifespan relative to the baseline of no college education. Prestigious private universities are: Hitotsubashi University, Keio University, Waseda University, Doshisha University and Meiji Gakuin University. Imperial universities are the top public institutions of higher education. Standard errors are clustered by birth year.
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Panel A: All Birth Prefectures

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<td></td>
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</tr>
</tbody>
</table>

Panel B: Birth Prefecture same as Residing Prefecture

Notes: This table reports OLS, and IV coefficients from regressions where the dependent variable is lifespan. The instrument is the log of the distance between an individual’s birth prefecture (capital city centroid) and Tokyo. The IV-interaction specifications include interactions between the instrument and gender as well as each occupation category. The placebo specifications use distance to a random city (Matsuyama, Ehime prefecture). All specifications include cohort and occupation fixed effects, controls for violent death and demographic controls. Standard errors clustered by birth prefecture. *p<0.1, **p<0.05, ***p<0.01.
**Figure 14: Meiji Era Lifespan and Education: Survival Probabilities**

**A: All Individuals**

**B: Men**

**C: Women**

**Notes:** These figures plot point estimates and 95% confidence to illustrate the relationship between college education and the likelihood of survival to a specific age within a panel dataset comprising 86 observations per individual (ages 20 to 105). Top panel estimates the college education effect for all individuals, middle panel for men only and bottom panel for women only. Regressions control for violent deaths, demographic characteristics and occupations. Standard errors are clustered by individual.
Figure 15: Meiji Era Lifespan and Education: Survival Probabilities by Occupation

A: Arts, Culture and Sports

B: Warriors and Military

C: Government and Politics
D: Religion and Spirituality

E: Scholars and Science

F: Business, Technology and Finance
**G: MISCELLANEOUS**

*Notes:* These figures plot point estimates and 95% confidence to illustrate the relationship between college education and the likelihood of survival to a specific age within a panel dataset comprising 86 observations per individual (ages 20 to 105). Regressions control for violent deaths, demographic characteristics and occupations. Standard errors are clustered by individual.