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Chilling Sunsets: Climate Distances and Later-Life Mortality of Immigrants

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Abstract
Previous research suggests that immigrants sort into environments that resemble their country of origin. However, fewer studies have examined whether this similarity/dissimilarity affects health outcomes. In this paper, we address this question using Social Security Administration death records linked to the full count 1940 census. We explore the effect of temperature distance, i.e. the difference between the average temperature of an immigrant's birth country and US county of residence, during midlife on later-life longevity. We find that a 5.5 °C change in temperature distance, equivalent to the mean of the sample, is associated with 3.3 months lower longevity. We find that these effects are largely driven by low-educated individuals and those in weather-related occupations for whom climate-specific skills play an important role. Further, we find comparable effects when we turn our focus on cross-county internal migrants of US-born individuals. We discuss the policy implication of these results in light of expected climate-driven migration in the population of immigrants in the US population in the coming decades.

Keywords Mortality · Longevity · Immigration · Climate exposure · Climate distance

JEL Codes I10 · J15 · Q54 · N31 · N32

1 Introduction

Global migration is shaped by a complex interplay of economic, demographic, and environmental factors, including population growth, labor market opportunities, and climate conditions. While existing evidence suggests that climate change can contribute to migration

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decisions, it remains one of several forces influencing global mobility (Bohra-Mishra et al. 2014; De Haas et al. 2019). Immigrants' sorting into destination places is driven by a wide array of factors that may spill over to their health and longevity. For instance, place-based policies, institutions, and economic conditions are major selection criteria among immigrants (Cadena and Kovak 2016). A growing line of research also points to the influence of these factors on health outcomes (Aizer et al. 2016; Noghanibehambari and Fletcher 2024). On the other hand, the sorting and settlement of immigrants is partly driven by climate matching, i.e., immigrants seeking areas and environments that resemble their place of origin (Obolensky et al. 2024; Steckel 1983). However, little is known whether the similarity or dissimilarity of environments between origin and destination places have impacts on immigrants' health outcomes. Specifically, fewer studies examine the legacies of climate distance, i.e., the extent of differences in birthplace and destination place climate, for immigrants' later-life mortality outcomes.

In this paper, we empirically investigate the effects of climate distance on immigrants' later life longevity in the United States. We employ death records of the US Social Security Administration linked with the full count 1940 census. The linked data allows us to observe the country of birth in addition to the county of residence post-migration, the county of residence in 1940, and the county of death. We find that the temperature difference between birth country and county of residence in the US is associated with mortality disadvantage. A higher temperature distance results in lower age at death. The effect appears to be symmetrical, i.e., moving to places with higher average temperature or lower average temperature compared with the average temperature of birthplace produces similar negative impacts on longevity. For instance, a 5.5 °C temperature distance (equivalent to the sample mean) is associated with 3.3 months lower longevity, compared to those migrating to counties with a similar temperature as their place of origin.

One possible explanation for the observed decline in longevity is rooted in the mismatch between environmental conditions experienced in early life and those encountered later in adulthood. A major hypothesis concerning fetal development (and the Developmental Origins of Health and Disease, DoHAD) is that individuals who experience large "mismatches" in environments between early life and later life are at a disadvantage in terms of reproduction and longevity (Hayward and Lummaa 2013). For example, scholars have shown that undernutrition in early life programs individuals to store calories throughout their life; this may be particularly detrimental and substantially increase the risk of obesity and metabolic syndrome in those people who subsequently live in a nutrient rich environment (Koletzko et al. 2012). Relatedly, individuals born in temperature conditions that are mismatched with the conditions in their later lives could also face disadvantages as their circulatory and other systems seek to make adjustments. Indeed, there is some evidence that large temperate differences between the in utero period and early childhood shorten longevity of males (Bruckner et al. 2014; Catalano et al. 2012).

One possible mechanism for the observed effects is climate-specific skills. We find that the negative effects of temperature distance on longevity are substantially larger for immigrants in occupations that depend heavily on climate, such as agriculture, forestry, and fishing. Moreover, the effects are more pronounced among low-educated immigrants, who are more likely to be employed in physically demanding jobs. We also provide empirical evidence that internal cross-county migration within the U.S. after immigration partially mitigates the adverse effects of environmental mismatch. Specifically, we find that the longevity penalties associated with temperature distance are significantly larger among immigrants who do not migrate again within the U.S., suggesting that secondary migration allows some individuals to relocate to regions with climates more similar to their country of origin. This pattern supports the idea that post-immigration migration serves as a corrective mechanism, reducing long-term exposure to climate mismatch and its associated health consequences.

We implement further tests to show that these results are not driven by changes in economic conditions, state-level policies, selective migration, measurement errors, or concentration of ethnic enclaves across counties. Moreover, although fewer people with climate-related occupations moved to areas with a higher temperature distance, we do not find convincing evidence that changes in sociodemographic and socioeconomic characteristics of immigrants in high versus low-temperature distance areas can explain the observed reductions in longevity.

We also examine cross-county migrants of US-born individuals. We observe similar patterns. Migrating to a county with a higher temperature distance is associated with reductions in longevity. The results are comparable if we consider the temperature distance between birth county and county of residence in 1940 (early-life to midlife migration) or the county of residence in 1940 and county of death (midlife to end-life migration). In addition, the point estimates of the longevity of internal migrants are surprisingly similar to those of international migrants.

Although we cannot formally examine the effects on mortality by cause of death due to data limitations, the observed relationship between temperature distance and mortality likely operates through multiple pathways, particularly those related to cardiovascular health, respiratory function, metabolic disorders, and mental health. Exposure to a climate that significantly differs from 1's birth environment can impose physiological stress as the body must adjust to new temperature extremes (Bruckner et al. 2014; Catalano et al. 2012; Obolensky et al. 2024). First, climate mismatch can increase cardiovascular stress—especially for migrants moving from colder to hotter climates, as their bodies may not be well-adapted to extreme heat exposure. These migrants may be more vulnerable to heat stress, dehydration, and chronic kidney disease (Bouchama et al. 2017; Cheng and Su 2010; Qu et al. 2023). Second, migrants who move from hot to colder climates may face higher risks of respiratory infections, circulatory diseases, and hypothermia (Mäkinen et al. 2009). Third, migrants settling in climates vastly different from their birth environment may experience higher stress levels, lower social integration, and limited community support, which are known risk factors for depression and other mental health problems (Pan et al. 2011). Furthermore, climate mismatch may alter lifestyle and physical activity patterns, potentially influencing the prevalence of obesity, diabetes, and circulatory diseases (Abdelaal et al. 2017).

Examining the influence of climate distance on immigrants' health outcomes has important policy implications for several reasons. First, immigration is projected to be a pivotal source of US population growth for the next decades, making a difference between population growth versus decline (Frey 2023). Further, with roughly 51 million immigrants, immigrants in the US account for about 14% of the country's population. Understanding factors that may contribute to lower health and longevity of this large subpopulation is policy-relevant. Second, given the likelihood that a mismatch in climate-specific skills contributes to the observed effects, our findings can inform the design of policies aimed at improving immigrants' adaptation strategies, skills, and human capital to better cope with new climate conditions. Third, climate change and global warming affect regions unevenly, and in many cases, they play a role in shaping migration patterns alongside economic and demographic factors (Bertoli et al. 2022; Cruz and Rossi-Hansberg 2023). One consequence is the shift in climate similarities both within countries and also for international migrants across countries that is going to unfold in the coming decades. Therefore, it is of policy relevance to understand the downstream effects of climate distance on immigrants' health outcomes.

This paper makes two important contributions to the literature. First, the results of this paper are among the first pieces of evidence to point to a link between climate distance and the longevity of immigrants. Shor and Roelfs (2019) implement a meta-analysis and show that immigrants who moved to countries with a relatively similar climate reveal a mortality advantage compared to native-born individuals. However, this advantage fades away for immigrants who migrate from a warmer country to a colder country, suggesting a link between temperature distance and mortality. Obolensky et al. (2024) show that immigrants seek out familiar climates. While their main focus is migration patterns, they also find that temperature distance between country of birth and U.S. county of death is associated with lower longevity. Our study differs in several important ways. First, we link historical census records, which allow for richer heterogeneity analyses and exploration of mechanisms. Second, while they focus on immigrants aged 65 and older who died between 1988 and 2005, our data include deaths from age 36 onward (1975–2005) and cover both European and non-European immigrants, rather than only post-1970, non-European arrivals. Our results, which include immigrants from both European and non-European countries, provide evidence of considerable heterogeneity based on region of origin, with larger impacts observed among immigrants from non-European countries.[1] Third, in analyzing migration, they use cross-census linking methods developed by Abramitzky et al. (2020), whereas we apply the linking rules provided by Price et al. (2021). The latter linking rules yield a substantially higher match rate, resulting in a considerably larger sample size. Fourth, our results suggest that each additional 1 °C in temperature distance reduces longevity by approximately 18 days, compared to 7 days in their study. This difference may stem from their focus on post-1970 immigrants, whereas we examine cohorts who arrived before 1940. Advances in agricultural technology and the wider availability of air conditioning in later decades likely reduced dependence on weather-related skills and eased adaptation to unfamiliar climates. These changes may have attenuated the effects of climate mismatch for more recent immigrants, leading to the smaller estimates reported in their study.

Second, we contribute to the growing literature that evaluates the impacts of life-cycle exposures on later-life old-age health and mortality outcomes. This literature focuses on various exposures, including place-based policies, family conditions, economic conditions, and environmental factors (Fletcher 2012, 2015; Lleras-Muney 2005; Noghanibehambari and Fletcher 2023). However, little attention has been paid to the complementarity between climate and type of occupation. The results of this paper show that climate distance affects the longevity of low-skilled individuals and weather-related occupations more than other groups, suggesting the role of human capital in climate-distance effects among immigrants. Additionally, this paper also makes a significant methodological contribution by constructing a novel dataset that links multiple historical and administrative data sources. Specifi-

[1] The first restriction (plus the death window and age 65 death age cut off) means that age at arrival is truncated at 30 (born in 1940, arrive in 1970, die in 2005) and also any older age migrants arriving in 1970 must live at least 18 years to be included in the death window.

cally, we combine four waves of full-count census data with Social Security Administration death records, including both Numident and DMF data, to track long-term mortality outcomes of immigrants.

The rest of the paper is organized as follows. Section 2 reviews data sources and sample selection. Section 3 discusses the econometric method. Section 4 goes over the results. Finally, we conclude the paper in Sect. 5.

2 Data and Sample

The primary source of data comes from the Social Security Administration Numerical Identification (hereafter, Numident) and the Death Master Files (hereafter, DMF). The Numident records cover deaths that occurred to both females and males during the years 1988–2005 and the DMF records cover deaths to male individuals over the years 1975–2005. The data is extracted from the Censoc Project (Breen et al. 2023; Breen and Osborne 2022; Goldstein et al. 2021). The data reports several geographic measures for birth and death as well as the exact timing of birth and death that helps us to calculate age at death. However, the Numident-DMF data has three important advantages compared with other alternative data sources that are useful for our research design. First, the data is linked to the 1940 full count census, which is extracted from (Ruggles et al. 2020). It allows us to observe the county of residence in 1940 in addition to a wide array of individual and family characteristics, including education and occupation. Second, the data contains information on the country of birth. Third, the data offers an initially large sample size and leaves us with large numbers of observations after restricting the foreign-born with available data. This makes the use of this data superior to many alternative data sources with substantially lower sample size that also has a link to the 1940 census, such as Health and Retirement Study and the National Longitudinal Mortality Study.

The climate data is extracted from the Global Surface Summary of the Day (GSOD) of the National Oceanic and Atmospheric Administration (NOAA) database (NOAA 2023). The data reports several climatic measures from roughly 9,000 stations worldwide from 1929 onward. However, the data coverage is limited for earlier years. Therefore, we use the average annual temperature for the period between 1950 and 1980 as a proxy for the earlier decades. This assignment is arguably valid given the fact that the sharp rises in global temperature occurred after 1980. For each country, we assign the average temperature of its capital. In Appendix H, we use the average country temperature extracted from Samborska (2024) and replicate the main results. We find coefficients that are very comparable to the main results of the paper.

For US counties, we use a weighted average of reported temperature across all stations in the country where weights are in proportion to the inverse of distance square. We then calculate the average temperature for the whole period for each county. Next, we merge the Numident-DMF data with the GSOD-NOAA temperature data based on each individual's birth country and the county of residence in 1940. We then calculate *temperature distance* as the absolute value of the difference between the average temperature of the birth country and the average temperature of the county of residence in 1940. As an alternative climate measure, we also calculate *precipitation difference* through the same procedure as we did for temperature distance.

To control for cohort-specific characteristics (including secular changes in cohort-specific life expectancy), we use the full count 1940 census to calculate for each focal individual the average age at death of the cohorts from their country of birth resided in their 1940 county and died in the same year. Further, to control for the influence of ethnic enclaves in health outcomes, we calculate the total number of people from the focal individual's birth country who resided in their 1940 county and died in the same year. We include these two variables as controls in our regressions.

For several complementary analyses, we need information on the county of childhood of those immigrants who arrived early in their lives. For this subset of immigrants, we can also extract parental characteristics. For this reason, we link individuals from their location in the 1940 census to previous historical full-count censuses 1900–1930. We employ linking rules provided by Price et al. (2021).[2] We extract the required information based on the "first census of observation". For instance, if the 1900–1940 match is successful, we use parental information of county of residence in 1940 individual's childhood characteristics. If not, we move to the 1910–1940 links, and so on.

Table 1 reports summary statistics of the final sample. The final sample includes 621,649 foreign-born individuals. The average age at death is 1,015 months, or 84.6 years. The average temperature distance is 5.5 °C. Given the fact that a considerable portion of the sample

Table 1 Descriptive statistics

	Mean	SD	Min	Max
Death age (month)	1015.0412	102.50659	434	1417
Temperature Distance between 1940-county and birth-country	5.45076	4.15615	0.00024	15.99482
Precipitation Distance between 1940-county and birth-country	8.726	6.85303	0.00234	138.62035
Female	0.19762	0.3982	0	1
White	0.98205	0.13277	0	1
Black	0.00405	0.06351	0	1
Hispanic	0.07899	0.26972	0	1
Other	0.0139	0.11708	0	1
Education = zero	0.04772	0.21317	0	1
Education < high school	0.61944	0.48552	0	1
Education = high school	0.28017	0.44908	0	1
Education = college-more	0.07816	0.26842	0	1
Education missing	0.02223	0.14745	0	1
Father SEI 1st quartile	0.08651	0.28112	0	1
Father SEI 2nd quartile	0.11105	0.3142	0	1
Father SEI 3rd quartile	0.05088	0.21975	0	1
Father SEI 4th quartile	0.08364	0.27685	0	1
Father SEI missing	0.66792	0.47096	0	1
Mother Literate	0.25235	0.43436	0	1
Mother Literate Missing	0.66966	0.47033	0	1
Average county-country-death-year age-at-death	1015.0412	56.41853	468	1417
Number of immigrants in county-country-death-year	83.81703	130.48475	2	921
Observations	621,649			

Notes. The data covers cohorts of 1880–1940 who died between 1975 and 2005

[2] Appendix L provides details about the Census Tree linking method developed by Price et al. (2021).

comes from the DMF data that report deaths to male individuals only, the share of females in the final sample is only 20%. The sample consists of mainly white individuals, accounting for 98.2% of observations. However, the Hispanic population of immigrants accounts for 7.8% of the final sample. About 4.7% of individuals have no education, 61.9% have less than a high school education, and about 28% have a higher school education. For about 33% of observations, we have information on paternal socioeconomic status and maternal literacy. For example, of those individuals with available maternal literacy information, about 25.2% have literate mothers. Figure 1 illustrates quartiles of temperature distance (top panel) and age at death (bottom panel) across US counties in the final sample.

The underrepresentation of women and nonwhite individuals in the Numident-DMF data (as outlined in Table 1) warrants further explanation. Among women, unmarried individuals are overrepresented due to more accurate name-based linkage. These patterns may introduce upward bias if the more successfully linked subgroups have better average longevity. The Numident dataset partially addresses this issue by including parental names, allowing for improved match rates among unmarried women, but the underrepresentation of women remains a significant limitation (Breen et al. 2023, Breen and Goldstein 2022; Breen and Osborne 2022). Hispanics are underrepresented in both the Numident and DMF datasets due to lower Social Security participation, selective migration, and reporting biases. Many Hispanic immigrants, especially those who arrived earlier, did not obtain Social Security numbers due to ineligibility or employment in informal sectors. As a result, they are excluded from administrative datasets that rely on SSN-based mortality tracking. Return migration further contributes to underrepresentation, as many Hispanic individuals died outside the U.S., where deaths were not captured by Social Security records. Even among those who remained, inconsistencies in death reporting—especially by family members or institutions less engaged with Social Security—further reduced coverage (Breen et al. 2023, Breen and Goldstein 2022; Breen and Osborne 2022). Selective return migration may contribute to the underrepresentation of Hispanics in the Numident and DMF datasets, potentially biasing our estimates. Studies suggest that return migrants often have poorer health, while those who remain in the U.S. exhibit a longevity advantage—sometimes even exceeding that of native-born Americans (Arenas et al. 2015; Diaz et al. 2016; Markides and Eschbach 2005). Consequently, our dataset may overrepresent healthier non-returning immigrants, and as a result, the estimated effects of temperature distance on longevity could be biased downward, underestimating the true impact across the full spectrum of immigrants.

Figure 2 depicts birth countries in the final sample based on their quartiles of temperature. In Table 2, we list these countries with the number of immigrants from each country present in our final sample. In Fig. 2, many countries of birth are listed as 'no data,' which reflects two key limitations in data collection. First, the availability of historical temperature data is restricted for certain countries in the period under study, as our temperature data is sourced from the NOAA database. Given our criteria for temperature data collection, we were able to extract temperature records for 61 countries, of which our final sample covers 55. Second, the process of data linkage, combined with the limited death window of 1975–2005, may have disproportionately underrepresented immigrants from countries with fewer recorded observations, leading to their exclusion from the final sample. Since a significant portion of the missing data stems from the lack of historical climate records, caution is necessary when generalizing our results to countries not included in the final sample. However, as shown in Fig. 2, many of the missing-value countries are located in Africa and South

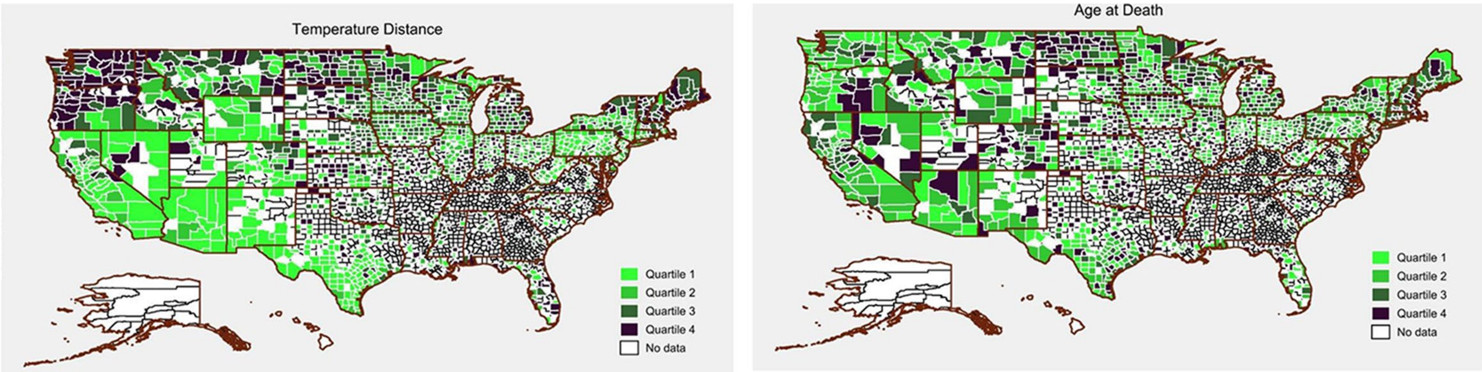

Fig. 1 Geographic distribution of temperature distance and age at death in the final Sample. Notes. The quartiles for temperature distance, defined as the difference between the average temperature of an immigrant's birth country and their U.S. county of residence in 1940, range from −15 °C to −0.39 °C in the first quartile, 0.39 °C to 3.40 °C in the second quartile, 3.41 °C to 7.00 °C in the third quartile, and 7.05 °C to 15.00 °C in the fourth quartile. The quartiles for age at death, measured in months, range from 629 to 990.71 months (approximately 52.4 to 82.6 years) in the first quartile, 990.74 to 1012.22 months (82.6 to 84.4 years) in the second quartile, 1012.25 to 1030.88 months (84.4 to 85.9 years) in the third quartile, and 1030.96 to 1274 months (85.9 to 106 years) in the fourth quartile

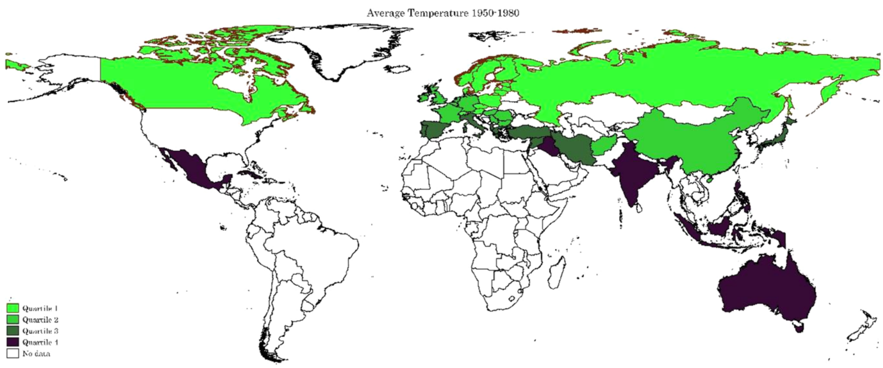

Fig. 2 Geographic distribution of temperature across birth countries. Notes. The quartiles for the average temperature of birth countries range from −1.08 °C to 7.91 °C in the first quartile, 8.23 °C to 11.34 °C in the second quartile, 13.72 °C to 19.16 °C in the third quartile, and 19.73 °C to 27.10 °C in the fourth quartile

Table 2 Birth countries in the final sample

Birth Country	N	Birth Country	N	Birth Country	N
Afghanistan	2	Malta	648	Greece	6975
American Samoa	4	Israel	682	Yugoslavia	7267
Singapore	6	Wales	1034	Norway	8632
Guam	10	Syria	1370	Puerto Rico	8794
Indonesia	11	Cuba	1555	Sweden	11633
Iraq	16	Japan	1696	Czechia	14382
Lebanon	20	Belgium	1933	Austria	19414
UK	26	Finland	2687	Hungary	22407
Gibraltar	34	Lithuania	2909	Ireland	22695
Cyprus	41	Spain	3016	Scotland	23506
Luxembourg	78	Denmark	3437	England	28693
Estonia	90	Turkey	3547	Mexico	34493
India	139	Switzerland	3554	Poland	43466
Iran	202	Philippines	3779	Germany	47259
Bulgaria	222	France	3997	Russian Federation	50062
Albania	431	China	4839	Canada	103097
US virgin	437	Romania	5403	Italy	108579
Australia	450	Netherlands	5592		
Latvia	453	Portugal	5945		

America, regions that were less economically developed in the early twentieth century. It is plausible that immigrants from these countries were more likely to work in weather-sensitive occupations, such as agriculture and manual labor, where temperature distance effects are expected to be stronger (see Section 4.2). Therefore, the exclusion of these countries due to data limitations may introduce a downward bias in our regression estimates, potentially underestimating the true impact of temperature distance on longevity.

3 Econometric Method

We implement the following fixed effect model to assess the impact of temperature distance on longevity:

$$y_{ibcd} = \alpha + \beta TD_{bc} + \gamma X_i + \lambda Z_{bcd} + \zeta_{bd} + \xi_{cd} + \varepsilon_{ibcd} \quad (1)$$

The outcome is the age at death of individual i who was born in country b and resided in county c (in 1940) and died in year d. The variable TD is the absolute value of the temperature difference between the birth country and the 1940 county. In X, we include individual and family covariates, including dummies for race, ethnicity, gender, education, paternal socioeconomic status, and maternal literacy. In Z, we include the average number of immigrants and the average age at death of immigrants from the same birthplace, in the same county, who died the same year.

Parameters ζ and ξ represent birth-country-by-death-year fixed effects and 1940-county-by-death-year fixed effects, respectively. These fixed effects account for all unobserved factors related to place of birth and county of residence that influence the longevity of individuals who died in the same year. Finally, ε is a disturbance term. Standard errors are two-way clustered on birth-country and 1940-county.

To examine the heterogeneity of the results across different temperature distance values, we also use regressions of the following form:

$$y_{ibcd} = \alpha + \sum_{i=\underline{T}}^{i=\bar{T}} \beta_i I\left(i \leqslant TD < i + 1\right) + \gamma X_i + \lambda Z_{bcd} + \zeta_{bd} + \xi_{cd} + \varepsilon_{ibcd} \quad (2)$$

In which $I(.)$ is a unit function that equals one if the temperature distance is within $[i,\ i + 1)$ range. All other parameters and variables are the same as in Eq. 1.

4 Results

4.1 Main Results

The main results of Eq. 1 are reported in Table 3. We observe fairly stable coefficients as we had more covariates across consecutive columns. The negative coefficients imply the mortality disadvantage associated with living in a different temperature climate compared to the country of origin. For example, a 5.5 °C higher temperature distance (equivalent to the mean temperature distance in the sample) is associated with 3.3 months lower longevity.[3] Since the measurement of temperature distance is based on the absolute value of the difference in temperatures, it raises the question of symmetry in the effects, i.e., whether the observed effects are driven due to residing in hotter or cooler areas compared with the temperature of the birthplace. To address this question, we implement the specification introduced in Eq. 2 and report the results in Fig. 3. In this figure, we eliminate the coefficient of those residing in areas within a 1 °C difference so that all point estimates are compared to the longevity

[3] Appendix D replicates the main results for individual countries containing observations more than 30K.

Table 3 Effect of exposure to temperature distance between 1940-county and birth-country on age-at-death of immigrants

	Outcome: Age-at-Death (Months)			
	(1)	(2)	(3)	(4)
Temperature Distance	−0.70046***	−0.78191***	−0.69672***	−0.59892***
	(0.20345)	(0.20208)	(0.18179)	(0.18064)
Observations	621649	621649	621649	621649
R-squared	0.14957	0.19597	0.3364	0.33672
Mean DV	1015.041	1015.041	1015.041	1015.041
County FE	✓	✓	✓	✓
Death Year FE	✓	✓	✓	✓
Country FE	✓	✓	✓	✓
County-by-Death-Year FE		✓	✓	✓
Country-by-Death-Year FE		✓	✓	✓
Individual/Family Controls			✓	✓
County Covariates				✓

Notes. Standard errors are in parentheses. Individual controls include gender, ethnicity, race, and education dummies. Family controls include maternal literacy and paternal socioeconomic status dummies. County-by-country-by-death-year covariates contain average number of immigrants and average age-at-death of immigrants. Standard errors are two-way clustered on 1940-county and birth-country. The data covers birth years of 1880–1940 who died between 1975 and 2005

FE stands for Fixed Effects

*** $p<0.01$, ** $p<0.05$, * $p<0.1$

of these individuals. As temperature distance moves away from this comparison group and becomes larger, we observe larger point estimates. For example, for observations residing in counties with 6-and-higher (°C) temperatures compared with their country of origin, the coefficients suggest a drop in longevity of about 7.3 months. We also observe a fairly similar pattern for negative temperature distances, i.e., residing in counties with lower average temperatures compared with birth country. However, for temperature differences of −2 and −3, we observe small and insignificant coefficients.[4]

As shown in Fig. 3, confidence intervals tend to be smaller for lower values of temperature distance and larger for coefficients associated with higher magnitudes of temperature distance. In Appendix Figure K4, we present the distribution of sample size across different temperature distance brackets. We observe larger sample sizes for smaller values of temperature distance and smaller sample sizes as temperature distance increases. Therefore, the larger confidence intervals in Fig. 3 may result from relatively smaller sample sizes in these temperature distance brackets.

It is important to note that our results estimate the relative loss in longevity due to temperature distance compared to migrants who moved to a U.S. county with a very similar climate to their birth country. Since the reference group may have experienced longevity gains due to migration-related factors such as improved healthcare and economic opportunities,

[4] While our main results are broadly symmetric, it is plausible that different mechanisms operate depending on the direction of the temperature change. For example, migrants relocating to colder climates may face increased cardiovascular strain, while those moving to hotter regions may experience greater heat stress and dehydration risk. Although we cannot separately identify these pathways, we acknowledge that distinct physiological or occupational challenges may underlie the observed effects (Shor and Roelfs 2019).

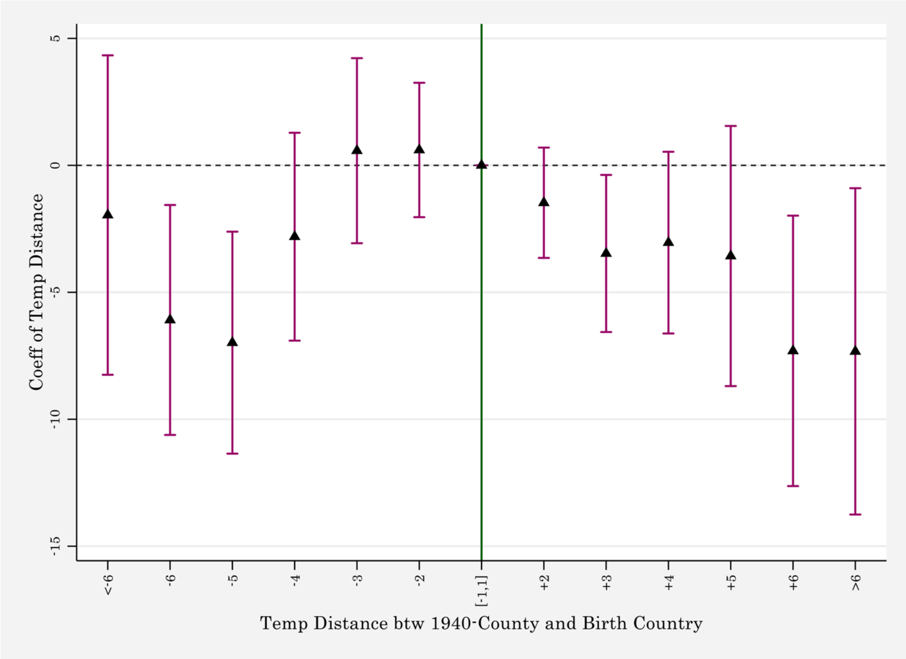

Fig. 3 Temperature distance and later-life mortality. Notes. Point estimates and 95% standard errors are depicted. The outcome is age at death in months. Regressions include 1940-county-by-death-year and birth-country-by-death-year fixed effects. Regressions also include individual, family, and county-by-country-by-death-year covariates. Individual controls include gender, ethnicity, race, and education dummies. Family controls include maternal literacy and paternal socioeconomic status dummies. County-by-country-by-death-year covariates contain average number of immigrants and average age-at-death of immigrants. Standard errors are two-way clustered on 1940-county and birth-country. The data covers birth years of 1880–1940 who died between 1975 and 2005

the observed effects should be interpreted as the relative disadvantage of climate mismatch rather than the absolute impact of migration.

One way to understand the magnitude of these effects is to compare them with other shocks and exposures that influence longevity. For instance, Noghanibehambari and Fletcher (2024) examine the effects of exposure to the Dust Bowl of the 1930s during childhood on old-age longevity and document a reduction of about one month for finely exposed individuals. Therefore, a 1.7 °C temperature distance may contain the same adverse effect as that of the infamous dust bowl and the resulting agricultural shocks. Fletcher and Noghanibehambari (2022) examine the effects of childhood exposure to lead in drinking water on later-life longevity. They document that exposure to lead service lines is associated with about a 2.7-month reduction in longevity. This effect is equivalent to a 4.5 °C change in temperature distance.

We can also focus on contemporaneous contributors to longevity as the comparison benchmark. For instance, Chetty et al. (2016) examine the association between household income longevity using the tax returns and mortality data for the years 1999–2014. They document a linear relationship between income percentile and age at death. For each additional percentile of income, age at death rises by about 7–9 months. Assuming a change relative to the mean annual household income, where one percentile of income is equivalent to roughly \$2K per year (in 2020 dollars) (U.S. Census Bureau 2023), we estimate that the effect of a 5.5 °C temperature distance on longevity (3.3 months) is comparable to a reduction in annual household income of approximately \$725–925.

Another way to put the results into perspective is by calculating the cost of life-years lost. In calculating life-years lost, we assign the average temperature distance effect from Fig. 3 to each temperature distance bracket among immigrants. For instance, for immigrants in the temperature distance bracket of −6° Celsius, we assign an effect of −6.1 months. We then calculate the total longevity loss for the entire sample using the assigned temperature distance effects. This calculation results in an estimated loss in longevity of approximately 100.6 thousand years. To calculate the costs associated with this number, we employ the concept of the Value of Statistical Life (VSL). Studies suggest a VSL of about \$10 M (in 2020 dollars) (Kniesner and Viscusi 2019). The average age at death in the final sample is 84.5 years. Therefore, the back-of-an-envelope calculation suggests a value of roughly \$118.3K for each additional year of life. Using this number and the total life years lost associated with the average temperature distance, we estimate a total cost of \$11.91 billion.

4.2 Heterogeneity by Skill and Migration

Cultural evolution allows for the accumulation of knowledge and techniques that are specific to an environment and a region and beneficial for the survival of people. This region-specific and climate-specific knowledge is multifaceted and appears in many aspects of individuals' lives. For instance, individuals may accumulate and transfer climate-specific methods of farming, pest management, seasonal timing, water management, soil health management, agroforestry practices, drought-resilient and flood-resilient farming, etc. Moreover, it can appear in adaptations to extreme heat or cold through insulation, ventilation, and various house construction techniques. Further, individuals may develop biological adaptation to the local climate. For instance, extreme heat exposure over generations may result in acclimatization, a physiological change marked by increased sweat production and improved heat tolerance. This process may also work for extreme cold exposure by an accelerated metabolic rate.

These adaptations can explain why extreme heat exposure results in higher temperature-related mortality in colder areas than hotter areas and why extreme cold exposures have larger mortality effects in relatively hot places than cold places (Barreca et al. 2015, 2016; Heutel et al. 2021). The fact that part of the adaptation is driven by climate-specific skills provides a testable hypothesis to examine potential mechanisms. In so doing, we interact a dummy variable indicating having a weather-related occupation (occupations in agriculture, forestry, fishing industries) with the temperature distance. We note that, in the analysis presented in this section, the temperature distance variable is de-meaned so that the main effects of the covariates are interpreted at the mean level of temperature distance—that is, among immigrants residing in locations with average climate mismatch.

The results are reported in column 1 of Table 4. The main effect of weather-related occupation implies a 10.1-month higher longevity when temperature distance is at the mean. On the other hand, we observe an interaction term that is considerably larger than the main effect, suggesting a 1-month drop in longevity for those in weather-related occupations.

Table 4 Heterogeneity across subpopulations

	Outcome: Age-at-Death (Months)			
	(1)	(2)	(3)	(4)
Temperature Distance × Weather-Related Occupation	−1.04427***			
	(0.21862)			
Weather-Related Occupation	10.08186***			
	(0.91289)			
Temperature Distance × Education < 9		−0.45212***		
		(0.15022)		
Education < 9		−1.15016*		
		(0.68084)		
Temperature Distance × non-Migrant			−0.40208***	
			(0.14978)	
Non-Migrant			2.80812***	
			(0.637)	
Temperature Distance × Ethnic Enclave Above-Median				−0.48488***
				(0.17531)
Ethnic Enclave Above-Median				−0.55079
				(0.83558)
Temperature Distance	−0.49807***	−0.27121	−0.44994**	−0.46979**
	(0.18401)	(0.21098)	(0.20294)	(0.19654)
Observations	621649	621649	146655	621649
R-squared	0.3371	0.3368	0.41462	0.33676
Mean DV	1015.041	1015.041	1035.459	1015.041

Notes. Standard errors are in parentheses. Regressions include 1940-county-by-death-year and birth-country-by-death-year fixed effects. Regressions also include individual, family, and county-by-country-by-death-year covariates. Individual controls include gender, ethnicity, race, and education dummies. Family controls include maternal literacy and paternal socioeconomic status dummies. County-by-country-by-death-year covariates contain average number of immigrants and average age-at-death of immigrants. Standard errors are two-way clustered on 1940-county and birth-country. The data covers birth years of 1880–1940 who died between 1975 and 2005

Non-migrant status is based on comparison between 1940-county and county-of-death, for observations with available information on place of death. Weather-related occupations include those in agriculture, forestry, and fishing industries

*** $p<0.01$, ** $p<0.05$, * $p<0.1$

Higher educated individuals are more likely to operate in service or professional occupations, have better health-related awareness, and their earning advantage provides insulation for climate-specific shocks. Therefore, it is not surprising to observe a larger coefficient for low-educated individuals compared to higher-educated individuals (column 2, Table 4). In this regression, the main effect of low education (i.e., fewer than 9 years of schooling) indicates a 1.2-month reduction in longevity compared to individuals with higher levels of education.

Another possible mitigating find is internal migration post-immigration. Immigrants may observe the obstacles and difficulties of living in high-temperature distance areas and decide to move to lower temperature distance areas in order to mitigate the adversaries. To assess whether these migrations produce any heterogeneity in the effects on longevity, we interact with the temperature distance variable a non-migrant dummy indicating that the individual remained in the county at the "first-census-of-observation" until 1940 and zero otherwise.

As reported in column 3 of Table 4, we observe similar coefficient for non-migrants (the interaction term) and migrants (the main effect of temperature distance), suggesting that within-US movements post-immigration did not influence the adverse effects of temperature distance on longevity.

4.3 Heterogeneity by Ethnic Enclaves

Immigrants may choose to settle in areas with a higher density of immigrants from their home country. These so-called ethnic enclaves may benefit the economic and health outcomes of immigrants through a variety of pathways including social support, greater networks, job opportunities, and information (Damm 2009; Osypuk et al. 2009). Therefore, those immigrants residing in unfamiliar places may face hardship not because of the climate distance but because of lower accessibility to these ethnic enclaves.

To empirically investigate the role of ethnic enclaves in the temperature-distance-longevity relationship, we use the full count 1940 census to calculate the share of immigrants from each birth country within each county to use as a proxy for the concentration of ethnic enclaves. We then interact a dummy variable indicating residence in an above-median ethnic enclave with the temperature distance variable. The results are reported in column 4 of Table 4. While residing in an area with a higher concentration of ethnic enclaves is associated with an insignificant decrease in longevity of approximately 0.6 months, the interaction term suggests that the effect of temperature distance is greater in areas with a higher concentration of ethnic enclaves. This is surprising as it suggests that these ethnic enclaves were not successful in mitigating the negative effects of climate distance on longevity. One explanation is that the higher concentration of ethnic enclaves correlates with a slower pace of assimilation and acculturation which is necessary to hinder the adverse effects of climate distance. Another explanation is that climate distance may interact with economic disparities and other social inequality measures to further influence longevity. Areas with a higher concentration of ethnic enclaves usually represent urban places with higher population density and also higher economic and social disparities (Gill 2019).

In Appendix I, we examine the correlation between ethnic enclave concentration and several observable characteristics. We find that ethnic enclaves are more concentrated in areas with climates similar to immigrants' countries of origin, as indicated by a negative correlation with temperature distance. We also observe that individuals in weather-related occupations and those with lower education levels are more likely to reside in higher enclave areas. These patterns may partly explain the negative interaction term in column 4 of Table 4, but they do not support the hypothesis that higher enclave concentration slows assimilation in a way that amplifies the adverse effects of climate distance.

4.4 Heterogeneity by Age at Migration

Another important factor that might interact with environmental mismatches to influence long-term health outcomes is the age at migration. Although the 1940 census does not provide information about the year of immigration, the 1900–1930 censuses provide this information. Using cross-census linking rules from Price et al. (2021), we locate a large portion of the sample in earlier censuses and calculate their age at migration to the

US.[5] We then replicate the main results for subsamples of individuals who migrated during childhood (ages 0–15) and those who migrated during early adolescence or adulthood. The results are reported in Appendix Table G1. We observe considerably larger point estimate for those who migrated during childhood, suggesting a reduction of 0.7 months in longevity. For those who migrated post-age-15, we find a reduction of 0.5 months. These results may reflect a combination of two effects: first, the adverse impact of climate mismatch on fathers, which may spill over to affect their children; and second, the heightened vulnerability of children to environmental mismatches during critical developmental periods, as suggested by the Developmental Origins of Health and Disease (DoHAD) framework (Gluckman et al. 2010; Gluckman and Hanson 2006; Godfrey et al. 2007). Early exposure to climates that differ significantly from those of the birthplace may disrupt physiological adaptations and developmental trajectories, leading to long-term health consequences. Additionally, younger migrants may inherit or assimilate climate-specific skills and behaviors less effectively, as these are typically learned from parents or communities rooted in the birthplace environment.

4.5 County of Childhood and Death

The analysis so far has focused on the temperature distance between the county of residence in 1940 and the birth country. We argue that focusing on the 1940-county is relevant as a great portion of the sample is of working age in 1940. Indeed, about 96.6% of observations were between 18 and 60 years old in 1940.[6] Given the fact that occupation-specific skills and human capital are likely the pathway between temperature distance and longevity, it is reasonable to focus on 1940-county rather than county of residence in other periods of life. However, we also show the results for the temperature distance between the birth country and county of residence at two alternative points of life: during childhood (the county of residence at the first census of observation) and at the time of death. These results are illustrated in the top and bottom panels of Fig. 4. The negative temperature distance coefficients for childhood county (the top panel) provide mixed evidence. However, the positive temperature distance coefficients provide consistent negative effects that are considerably larger than those of Fig. 3. The negative temperature distance coefficients of the death county (the bottom panel) suggest larger drops in longevity as we move away from the comparison group. However, we do not find statistically different coefficients for positive temperature distance coefficients for several temperature bins. The only significant coefficient is for temperature distance of 6-and-more which suggests a 4.5-month drop in age at death.

The regression results of Eq. 1 based on death-county are reported in column 1 of Table 5. The point estimate for the temperature distance of death-county suggests a significant

[5] Appendix Figure K-2 illustrates the distribution of immigrants in the death data by year of arrival and country of origin. Appendix Figure K-3 presents the distribution of immigrants in the death data, as well as in the original population of the 1940 Census, based on birth cohort and country of origin.

[6] Appendix Figure K-1 shows the density distribution of age in 1940 for both the final sample and the original population of immigrants from which the final sample was extracted. Visually, observations in the final sample appear to be relatively younger than those in the original population. However, this difference in age distribution may affect the results if it correlates with temperature distance. As discussed in section 4.10 and Appendix B, temperature distance is uncorrelated with the probability of being included in the final sample from the original population of immigrants in the 1940 Census. Therefore, such observable differences in the distribution are also unlikely to be correlated with temperature distance and, consequently, are unlikely to introduce selection bias.

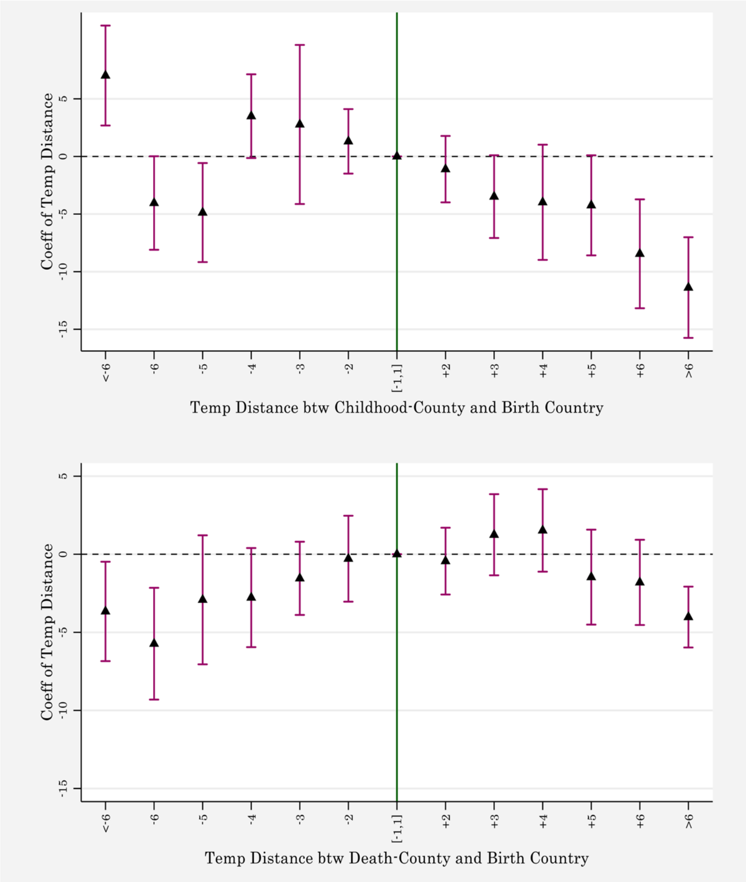

Fig. 4 Temperature distance in childhood-county (Top) and death-county (Bottom) and later-life mortality. Notes. Point estimates and 95% standard errors are depicted. The outcome is age at death in months. Regressions include 1940-county-by-death-year and birth-country-by-death-year fixed effects. Regressions also include individual, family, and county-by-country-by-death-year covariates. Individual controls include gender, ethnicity, race, and education dummies. Family controls include maternal literacy, paternal literacy, and paternal socioeconomic status dummies. County-by-country-by-death-year covariates contain average number of immigrants and average age-at-death of immigrants. Standard errors are two-way clustered on 1940-county and birth-country. The data covers birth years of 1880–1940 who died between 1975-2005

drop of about 0.2 months in longevity. Since the sample becomes considerably smaller in size for observations with available death county information, we replicate the main results based on 1940 county using the subsample of column 1 and report the results in column 2. In columns 3–4, we examine the heterogeneity based on cross-county migration post-immigration between 1940 and death (1975–2005). The motivation behind this analysis stems from the fact that internal migration is one of the adaptation strategies that individuals employ to optimize their health and well-being (Heutel et al. 2021). We observe a point estimate among non-migrants that is twice the size of that of migrants.

Table 5 Temperature distance and mortality for childhood-county and death-county

	Outcome: Age-at-Death (Months), Samples:							
	Subsample with Information on Death County	Subsample with Information on Death County	Subsample with Information on Death County; Migrants [from 1940 to Death]	Subsample with Information on Death County; Non-Migrants [from 1940 to Death]	Subsample with Information on Childhood County	Subsample with Information on Childhood County	Subsample with Information on Childhood County; Migrants [from Childhood to 1940]	Subsample with Information on Childhood County; Non-Migrants [from Childhood to 1940]
	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
Temperature Distance between Birth-Country and Death-County	−0.20819***							
	(0.06507)							
Temperature Distance between Birth-Country and Childhood-County					−0.46323**			
					(0.20236)			
Temperature Distance 1940		−0.58023***	−0.42831	−0.86148***		−0.60908***	−0.54673***	−0.82682***
		(0.19788)	(0.26449)	(0.28387)		(0.18143)	(0.21171)	(0.1937)
Observations	146655	146655	97902	47101	620852	620852	171637	442907
R-squared	0.41442	0.41442	0.42759	0.46317	0.33671	0.33672	0.34636	0.38624
Mean DV	1035.459	1035.459	1034.923	1036.462	1015.069	1015.069	1026.629	1010.538

Notes. Standard errors are in parentheses. Regressions include 1940-county-by-death-year and birth-country-by-death-year fixed effects. Regressions also include individual, family, and county-by-country-by-death-year covariates. Individual controls include gender, ethnicity, race, and education dummies. Family controls include maternal literacy and paternal socioeconomic status dummies. County-by-country-by-death-year covariates contain average number of immigrants and average age-at-death of immigrants. Standard errors are two-way clustered on 1940-county and birth-country. The data covers birth years of 1880–1940 who died between 1975 and 2005

*** $p<0.01$, ** $p<0.05$, * $p<0.1$

Further, the regression results based on childhood county are reported in column 5. In column 6, we report the results of temperature distance based on 1940 county using the subsample of column 3. The coefficient of temperature distance of the childhood-county points to a 0.5-month reduction. In addition, both columns 5 and 6 suggest similar estimates to those of the main analysis sample. If the main pathway of effects operates through climate-specific skills (as discussed in Sect. 4.2), then it is not surprising that the measure of exposure during the working age (1940) provides a higher impact compared with childhood or old age.

In addition, we examine heterogeneity by migration status between childhood county and 1940 county. These results are reported in columns 7–8. Similar to the results of columns 3–4, we observe larger coefficients for the subsample of non-migrants, suggesting that internal migration might have been an effective strategy among immigrants to insulate the negative impacts of climate distance.

4.6 Effects on Fertility

A key DoHAD hypothesis suggests that individuals facing significant early-to-late-life environmental mismatches experience disadvantages in reproduction and longevity (Hayward and Lummaa 2013). While our results thus far demonstrate effects on longevity, we examine reproductive outcomes in Appendix J. Restricting the sample to individuals aged 20 and older, we implement regressions similar to Eq. 1, using the number of children in the 1940 census as a proxy for fertility.[7] We find that a 1 °C increase in temperature distance reduces fertility by 0.01 children on average. Similar effects emerge for binary outcomes indicating having more than two, three, or four children. For instance, each additional 1 °C increase in temperature distance is associated with a 0.72% reduction in the probability of having more than two children.

4.7 Robustness Checks

4.7.1 Balancing Tests

The results so far suggest that migration to places with radically different environments may have long-lasting consequences for longevity. In this section, we examine the robustness of our findings. The first concern in interpreting our results comes from the fact that there have been compositional changes among immigrants over the years (Abramitzky and Boustan 2017). If the characteristics of immigrants moving to lower versus higher temperature distance areas are different and those characteristics correlate with their health and longevity, the estimated effects pick up on those features rather than temperature distance. We empirically test this concern by regressing a series of pre-determined observable characteristics on temperature distance, conditional on fixed effects. The results are reported in Table 6. Female immigrants are less likely to reside in higher temperature distance areas (column 1). However, the implied magnitude is small compared with the mean of the outcome, suggesting a 0.75% change unit of temperature distance. We do not observe a significant change in the share of whistes (column 2) or Hispanics (column 4). We observe small increases in the

[7] This variable captures the number of own children living in the household, reported for both male and female respondents aged 20 and older.

Table 6 Balancing tests: temperature distance and sociodemographic characteristics

	Outcomes			
	Female	White	Black	Hispanic
	(1)	(2)	(3)	(4)
Temperature Distance	−0.00149***	−0.00009	0.00048***	−0.00009
	(0.00043)	(0.00026)	(0.00011)	(0.00007)
Observations	621649	621649	621649	621649
R-squared	0.27671	0.6541	0.23178	0.97349
Mean DV	0.198	0.982	0.004	0.079
	Education ≤ 12	Education Missing	Weather-Related Occupation	Father SEI < Median
	(5)	(6)	(7)	(8)
Temperature Distance	−0.00357***	−0.00056*	−0.00438***	−0.0028***
	(0.00071)	(0.00032)	(0.00063)	(0.0007)
Observations	621649	621649	621649	621649
R-squared	0.07074	0.06799	0.32746	0.10814
Mean DV	0.900	0.022	0.050	0.198
	Father SEI ≥ Median	Father SEI Missing	Mother Literate	Mother Literacy Missing
	(9)	(10)	(11)	(12)
Temperature Distance	0.00039	0.00241***	−0.00398***	0.00392***
	(0.00067)	(0.00082)	(0.00082)	(0.00094)
Observations	621649	621649	621649	621649
R-squared	0.08172	0.1091	0.10688	0.09491
Mean DV	0.135	0.668	0.252	0.670

Notes. Standard errors are in parentheses. Regressions include 1940-county-by-death-year and birth-country-by-death-year fixed effects. Standard errors are two-way clustered on 1940-county and birth-country. The data covers birth years of 1880–1940 who died between 1975 and 2005

*** $p<0.01$, ** $p<0.05$, * $p<0.1$

share of Blacks (column 3). Further, we observe a negative association between temperature distance and low education (column 5). However, the point estimate is quite small in magnitude, implying only a 0.3% change with respect to the mean of the outcome.

In column 7, we observe a negative, significant, and comparably large association between temperature distance and weather-related occupation. The point estimate implies an 8.6% change from the mean. The negative coefficient suggests that individuals whose main occupation is in agriculture, forestry, and fishing industries are less likely to migrate to counties with a higher temperature distance.

For this subset of individuals that we are able to extract parental information from linking the 1940 records to historical censuses 1900–1930, we also examine the association between temperature distance and paternal socioeconomic status and maternal literacy in columns 8–12. While several of the coefficients are statistically significant, they are very small in magnitude. Further, these point estimates do not provide consistent, robust, and meaningful changes in the sample's sociodemographic and socioeconomic composition in a way that confounds our main results.

While the point estimates in Table 7 are small, they suggest mild non-random selection into destination counties. In particular, education and occupation show some correlation

Table 7 Robustness checks

	Column 4 of Table 3	Adding 1940-State by Birth-Country FE	Adding Birth-Month and Death-Month FE	Outcome: Log Age-at-Death	Outcome: Age at Death $\geq$ 65
	(1)	(2)	(3)	(4)	(5)
Temperature Distance	-.59892***	-.49694**	-.59558***	-.00062***	-.00031*
	(.18064)	(.21689)	(.1807)	(.00019)	(.00017)
Observations	621649	621649	621649	621649	621649
R-squared	.33672	.34208	.3371	.33424	.10653
Mean DV	1015.041	1015.041	1015.041	6.917	0.976
	Outcome: Age at Death $\geq$ 70	Outcome: Age at Death $\geq$ 75	Huber-White Robust Standard Errors	Using Censoc-Weights	Birth Cohort < 1925
	(6)	(7)	(8)	(9)	(10)
Temperature Distance	-.00124***	-.00153***	-.59892***	-.47083***	-.51296***
	(.00033)	(.00056)	(.07942)	(.14364)	(.17498)
Observations	621649	621649	621649	328178	611722
R-squared	.151	.19871	.33672	.49305	.35282
Mean DV	0.932	0.842	1015.041	1015.810	1018.305

Notes. Standard errors are in parentheses. Regressions include 1940-county-by-death-year and birth-country-by-death-year fixed effects. Regressions also include individual, family, and county-by-country-by-death-year covariates. Individual controls include gender, ethnicity, race, and education dummies. Family controls include maternal literacy and paternal socioeconomic status dummies. County-by-country-by-death-year covariates contain average number of immigrants and average age-at-death of immigrants. Standard errors are two-way clustered on 1940-county and birth-country (except in column 8). The data covers birth years of 1880–1940 who died between 1975-2005.

*** $p < 0.01$, ** $p < 0.05$, * $p < 0.1$

with temperature distance. Although these associations are modest, they raise the possibility that unobserved characteristics linked to both migration decisions and longevity may partly confound our estimates. This consideration is especially relevant for interpreting the heterogeneity analysis in Table 4, as both education and weather-related occupation are correlated with temperature distance.

4.7.2 Alternative Specifications

In Table 7, we further examine the robustness of the results to alternative specifications. In column 1, we replicate the results of column 4 of Table 3 as a benchmark comparison. In column 2, we add 1940-state-by-birth-country fixed effects to compare longevity outcomes of immigrants from the same birth country who reside in the same state in counties with differential temperature distances. This restriction limits the variation in the treatment but we observe a comparable coefficient that implies a drop in the magnitude of only 16% compared with that of column 1.

Several studies provide evidence of the influence of the season of birth in determining old-age longevity (Vaiserman 2021). There is also a line of research that documents seasonality and mortality outcomes (Xuan et al. 2014). To account for these potential confounding influences, we add dummies for birth-month and death-month and report the results in column 3. The estimated coefficient is very similar to column 1.

To check the sensitivity of the functional form, we replace the outcome with the log of age at death. The results are reported in column 4. Each additional unit of temperature distance (°C) in longevity by about 0.06%. This is almost identical to the implied percentage change of the coefficient in column 1 with respect to the mean of age at death. Further, we replace the outcome with a dummy variable indicating longevity beyond 65, 70, and 75 years and report the results in columns 5–7, respectively. We observe negative and significant associations for all these outcomes. When we compare the coefficients to the mean of their respective outcome, we find larger implied changes for longevity of older ages. For instance, we find a reduction of about 0.18% for longevity beyond age 75 while a reduction of 0.03% for longevity beyond age 65. Therefore, temperature distances may have delayed effects and appear at much older ages. This observation implies that climate mismatch may contribute to a decline in longevity due to aging -related factors. One explanation is that adverse climate conditions (in comparison with birth country) may contribute to cumulative stress and epigenetic changes, or changes health trajectories in earlier years of life in a way that the effects manifest at older ages. Additionally, regarding the role of weather-related occupations (Sect. 4.2), one possibility is that the long-term exposure to environmental mismatch contribute to chronic conditions that shorten lifespan even after individuals have left the workforce. Nonetheless, future research may access whether climate mismatch influences the likelihood of dying at younger ages (e.g., before age 65).

In column 8, we show the robustness of standard errors by implementing Huber-White robust standard errors. The estimated standard errors become even smaller than those of column 1.

The dataset includes individuals born between 1880 and 1940, with mortality records spanning 1975 to 2005, which introduces selection bias due to survival. Since only individuals who survived long enough to be included in the Social Security Administration's mortality records are observed, those who died before 1975—due to early-life health conditions or other lifecycle factors—are excluded. This survivor bias may disproportionately affect certain groups, such as lower-income individuals, minorities, and immigrants, potentially distorting estimates of the impact of temperature distance on longevity. To address this issue, we apply CenSoc-provided post-stratification weights, which adjust for differential survival probabilities using vital statistics data from the National Center for Health Statistics (NCHS). The weights are constructed using inverse probability weighting (IPW) to adjust for differential representation of individuals in the Numident – DMF data compared with the full count death records of the NCHS data (Osborne 2023). More specifically, these weights account for differences in survival rates across age, year of birth, sex, race, and place of birth, correcting for the fact that some subgroups—such as historically disadvantaged racial and ethnic minorities or immigrants—may have differential survival probabilities. Additionally, the weighting procedure includes adjustments for extreme weights and non-coverage of certain demographic groups. In column 9, we use Censoc-provided weights in our regression. Although the coefficient drops in magnitude, it is fairly comparable to that of column 1.

The period of 1929–1940 experienced the Great Depression, the Dust Bowl, and the introduction of large-scale federal social insurance benefits under the New Deal programs. Several studies examine the impacts of exposure to these conditions on later-life health and longevity (Arthi 2018; Modrek et al. 2022; Noghanibehambari et al. 2024; Noghanibehambari and Engelman 2022; Noghanibehambari and Fletcher 2024). To control for the potential influence of this volatile period in our results, we exclude cohorts born after 1925.

These results are reported in column 10. We observe a very similar coefficient compared with column 1.

4.7.3 Selective Migration

Immigrants are often a highly selective group, with their motivations for migration affecting their post-migration health outcomes. Research on international migration frequently proxies migration motivation using the costs or barriers associated with the migration process (Fafchamps and Shilpi 2013). For instance, the physical distance between an individual's place of birth and their destination provides an imminent and measurable barrier which correlates with immigrants' motivation for migration. Further, distance may be associated with immigrants' socio-economic performance at the destination, as those willing to undertake longer journeys may exhibit higher levels of determination, resourcefulness, or economic preparedness. This selectivity could contribute to their health outcomes, with more motivated/resourceful immigrants potentially accessing better healthcare services or adopting healthier lifestyles at their destination.

If the results are polluted with these selections, the accounting for physical/social barriers might add a downward bias to the coefficients. In Appendix E, we examine the robustness of the estimates to including measures of income-rank distance and physical distance into regressions. In so doing, we use data from Mayer and Zignago (2011) and calculate the distance between birth country and 1940 county. We also extract data from Roser et al. (2023) for cross country GDP per capita between the years 1920–1950. We calculate deciles of income per capita for birth countries. Using the 1940 census, we also calculate wage income deciles for counties. We then calculate the income-rank distance between birth country and 1940 county. As reported in different columns of Appendix Table E1, none of these measures make a discernible difference in the estimated coefficient. Additionally, we can calculate the North-South and East-West distances between the birthplace and the county in 1940, and include them as additional regressors. The results are presented in Appendix Table E2. The point estimates increase in magnitude when the North-South distance measure is included, but remain robust and similar to the main results when the East-West distance measure is added.

4.8 Measurement Error

There are two concerns related to construction of the temperature distance variable. First, measurement errors in county-level temperatures may not be random. Counties in the western United States are substantially larger than those in other regions. Furthermore, the distribution of immigrants by origin is uneven, with a higher concentration of Asian and Hispanic immigrants in western counties and more European immigrants on the East Coast. As a result, these measurement errors could be correlated with unobserved factors influencing health outcomes. To investigate the degree and direction of bias due to this measurement error, we split the sample into small and large counties (below and above median of county area) and replicate the main regressions. These results are reported in Appendix Table F1. We observe considerably larger coefficient in counties that are smaller, implying that such measurement errors might, at worst, add a downward bias into our regressions. One possible explanation for the larger coefficients observed in smaller counties is that smaller counties tend to have less diverse microclimates, meaning that individuals experience a more uniform environmental exposure. In contrast, larger counties may encompass multiple climate zones, making it harder to precisely measure an individual's true climate exposure, potentially introducing attenuation bias in larger counties.

Second, using capital cities' average temperatures to assign birth country temperatures introduces measurement errors, especially for large countries like China, Russia, and Canada. Moreover, in many countries, capital cities may not reflect the climate of regions with higher emigration rates. To assess the relevance of this measurement error, we implement sample selections to exclude larger countries. These results are reported in Appendix Table F2. As we focus on subsamples consisting of smaller countries, the estimated coefficient rise in magnitude, suggesting that these measurement errors might add a downward bias.

4.9 Results of Internal Migrants

So far, we focused on international migrants in the difference between their country's climate and the destination county's climate. One interesting avenue with potential policy implications is whether the results hold when we examine the temperature-distance-longevity associations for cross-county internal migrants. In so doing, we start with the full sample of Numident-DMF data linked to the 1940 census with observations that contain information regarding their county of death. The sample includes about 7.4 million observations. We merge this with the GSOD-NOAA climate data for the county of residence in 1940 as well as the county of death. We calculate temperature difference as the absolute value of the average temperature difference between the 1940-county and death-county. We then replicate the regression results of Table 3 and report them in panel A of Table 8. We observe fairly robust coefficients across columns. A rise of 2 °C in temperature distance (equivalent to the mean of the sample) is associated with a 2-month reduction in longevity.

Next, we follow the same linking procedure explained in Sect. 2 in order to extract the county of childhood (i.e., the county at the first census of observation). We calculate the temperature distance as the difference in temperature between the county of childhood and the county of death. We then replicate the regression results and report them in panel B of Table 8. We find that an increase of 2.1 °C in temperature distance (equivalent to the mean of the sample) is associated with a 1.5-month reduction in longevity.

Although both panels suggest point estimates that are larger than those of Table 3, these results also support the earlier findings that temperature distance, even for internal migrants, has long-lasting consequences for health and longevity.

4.10 Additional Analysis

In the main analysis of the paper, we focus on temperature distance as it contains essential information regarding climate. In Appendix A, we also add precipitation distance to our regressions. Since there is less information on precipitation, the sample size becomes considerably smaller. Moreover, the coefficients of precipitation distance become small and insignificant as we start to add covariates to the model. In Appendix Figure A1, we further investigate the heterogeneity in the effects of precipitation distance in the regressions of Eq. 2. We observe that for most areas with a negative distance (i.e., lower precipitation in the 1940-county compared with birth-country), the coefficients revealed a significant drop in

Table 8 Replicating the main results for within-US Migrants

	Outcomes:			
	(1)	(2)	(3)	(4)
Panel A. Migration between 1940-County and Death County				
Temperature Distance	-1.17975***	-1.18734***	-.95159***	-1.01719***
	(.1024)	(.10212)	(.06477)	(.06925)
Observations	7419313	7413007	7413007	7363130
R-squared	.12746	.13697	.53314	.5385
Mean DV	919.968	920.099	920.099	919.495
Panel B. Migration between Childhood-County and Death County				
Temperature Distance	-.61854***	-.62545***	-.60106***	-.72966***
	(.07596)	(.07519)	(.04726)	(.05447)
Observations	7419313	7413007	7413007	7363130
R-squared	.12655	.13606	.53267	.53806
Mean DV	919.968	920.099	920.099	919.495
County FE	✓	✓	✓	✓
Death Year FE	✓	✓	✓	✓
Country FE	✓	✓	✓	✓
County-by-Death-Year FE		✓	✓	✓
Country-by-Death-Year FE		✓	✓	✓
Individual/Family Controls			✓	✓
County Covariates				✓

Notes. Standard errors are in parentheses. Individual controls include gender, ethnicity, race, and education dummies. Family controls include maternal literacy and paternal socioeconomic status dummies. County-by-country-by-death-year covariates contain average number of immigrants and average age-at-death of immigrants. Standard errors are two-way clustered on 1940-county and birth-country. The data covers birth years of 1880–1940 who died between 1975-2005.

FE stands for Fixed Effects

*** $p<0.01$, ** $p<0.05$, * $p<0.1$

longevity. However, the effects are asymmetrical. For positive precipitation distance coefficients (i.e., destination places where precipitation is more than country of origin), the coefficients become very small and indistinguishable from zero. However, this pattern does not hold when we focus on earlier counties of residence (childhood county or county at first census of observation, middle panel in Appendix Figure A1) or later counties of residence (death county, bottom panel of Appendix Figure A1). This is in line with the findings of Deschênes and Moretti (2009) who document mortality disadvantage for extreme cold and extreme hot episodes but find no apparent influence of precipitation in mortality outcomes.

Another concern in the main results is related to endogenous data linking. For instance, it could be the case that individuals who reside in lower temperature distance locations (with lower mortality disadvantage) are more likely to be linked between the 1940 census to Numident-DMF data. In this case, the over-representation of individuals with lower mortality disadvantage results in underestimation of the effects. To address this concern, we start with the original population of all immigrants from countries listed in Table 2 in the full count 1940 census. We link these individuals to Numident-DMF records and generate a dummy variable indicating successful merging. We then regress the successful merging dummy on temperature distance between birth-country and 1940-county conditional on country and county fixed effects. These results are reported in Appendix B. In the full sample and various subsamples based on observable characteristics, we observe point estimates that are indistinguishable from zero, economically and statistically. These results rule out the concern over differential characteristics of linked versus unlinked individuals.

The death records of Berkeley Unified Numident Mortality Database (BUNMD) data have the advantage of a much larger sample size compared with Numident-DMF data.[8] We employ this data to replicate the main results as an alternative data source. The BUNMD data is not linked to the 1940 census but contains the essential information required for our research design: country of birth, county of death, and exact age at death. We employ this information and merge it with the GSOD-NOAA climate data to calculate temperature distance. We then replicate the main results using the BUNMD sample. These estimates are reported and discussed in Appendix C. We observe slightly larger but comparable point estimates. For instance, a 7 °C increase in temperature distance (equivalent to the mean of temperature distance in the BUNMD sample) is associated with 5.9 months lower longevity.

5 Conclusion

International migration has been steadily increasing due to global economic shifts, demographic pressures, political instability, and environmental changes, making it a defining feature of the modern world (Abel and Sander 2014; OECD 2024). The sorting and settlement of immigrants is partly driven by climate matching, i.e., immigrants seeking areas and environments that resemble their place of origin (Obolensky et al. 2024). However, little is known whether the similarity or dissimilarity of environments between origin and destination places have impacts on immigrants' health outcomes. This is an important policy question given the expected waves of climate-change-driven migration in the coming decades and the fact that international immigrants are the main projected driver of population growth in the US (Burzyński et al. 2021; Cattaneo et al. 2019; Frey 2023). In this paper, we addressed this question by evaluating the effect of temperature distance experienced during midlife on old-age longevity.

We employed Social Security Administration death records (1975–2005) linked to the full count 1940 census and focused on immigrants from 54 countries. We showed that temperature distance, i.e., the difference between the average temperature of the county of residence in 1940 and birth country, is negatively associated with longevity later in life. For instance, a 5.5 °C change in temperature distance is associated with 3.3 months lower longevity. We provided evidence that these results are mainly driven by low-educated individuals and those in agriculture, forestry, and fishing industries for whom weather and climate are important elements as occupation-related skills.

In 1940, cross-country life expectancy varied from 31.3 years (Afghanistan) to 48.9 (Japan), a difference of 17.6 years. The impact of average climate distance among immigrants in the US by 1940 on longevity (3.3 months) is roughly 1.6% of cross-country differences in life expectancy. Moreover, we can extrapolate this effect to all immigrants in the US in 1940 (assuming similar effects for observations that are not linked to death records) in order to calculate the total life-years lost across all immigrants. Based on the full count 1940 census, there were 11.8 million immigrants in the country. Therefore, we estimate 3.3

[8] Death year coverage of BUNMD data spans 1987–2007. This is slightly different than Numident-DMF coverage of 1975–2005.

million life-years lost to that immigrant population due to the temperature distance between their county of residence and their birth country. It is important to note that our estimates reflect the relative loss in longevity due to temperature distance, measured against immigrants who moved to a U.S. county with a climate similar to their birth country. This means that our findings should not be interpreted as the overall effect of migration on longevity but rather as the specific disadvantage associated with climate mismatch.

While our empirical approach includes rich controls, fixed effects, and a battery of robustness checks, several limitations remain. First, we approximate sending-region climates using capital-city temperatures, which may introduce measurement error, especially for immigrants from climatically diverse countries. Second, our analysis does not observe post-1940 internal migration. If immigrants relocate within the U.S. after 1940 in response to climate preferences or economic opportunities, our temperature mismatch measure may become bias estimates toward zero. Third, we focus on first-generation immigrants observed in the 1940 Census, but mortality is measured decades later; therefore, differential survival or emigration prior to death may introduce selection bias. Finally, our mechanism analysis could improve by exploring the effects on mental health, physiological stress adaptation, or access to medical care which remain outside the scope of our data.

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Data Availability The data used in this study is available upon request from the corresponding author.

Declarations

Conflict of Interest The authors claim that they have no conflict of interest to report.

References

Abdelaal M, le Roux CW, Docherty NG (2017) Morbidity and mortality associated with obesity. Ann Transl Med 5(7):161

Abel GJ, Sander N (2014) Quantifying global international migration flows. Science 343(6178):1520–1522

Abramitzky R, Boustan L (2017) Immigration in American economic history. J Econ Lit 55(4):1311–1345. https://doi.org/10.1257/JEL.20151189.

Abramitzky R, Boustan L, Rashid M (2020) *Census linking project: version 1.0* [*dataset*]. https://censuslinkingproject.org

Aizer A, Eli S, Ferrie J, Muney AL (2016) The long-run impact of cash transfers to poor families. The Am Econ Rev 106(4):935–971. https://doi.org/10.1257/AER.20140529.

Arenas E, Goldman N, Pebley AR, Teruel G (2015) Return migration to Mexico: does health matter? Demography 52(6):1853–1868

Arthi V (2018) "The dust was long in settling": human capital and the lasting impact of the American dust bowl. J Econ Hist 78(1):196–230. https://doi.org/10.1017/S0022050718000074.

Barreca A, Clay K, Deschenes O, Greenstone M, Shapiro JS (2016) Adapting to climate change: the remarkable decline in the US temperature-mortality relationship over the Twentieth Century. J Polit Econ 124(1):105–159. https://doi.org/10.1086/684582/ASSET/IMAGES/LARGE/FG5AB.JPEG.

Barreca A, Clay K, Deschênes O, Greenstone M, Shapiro JS (2015) Convergence in adaptation to climate change: evidence from high temperatures and mortality, 1900-2004. The Am Econ Rev 105(5):247–251. https://doi.org/10.1257/AER.P20151028.

Bertoli S, Docquier F, Rapoport H, Ruyssen I (2022) Weather shocks and migration intentions in Western Africa: insights from a multilevel analysis. J Econ Geogr 22(2):289–323. https://doi.org/10.1093/JEG/LBAB043.

Bohra-Mishra P, Oppenheimer M, Hsiang SM (2014) Nonlinear permanent migration response to climatic variations but minimal response to disasters. Proc Natl Acad Sci USA 111(27):9780–9785. https://doi.org/10.1073/PNAS.1317166111/SUPPL_FILE/PNAS.201317166SI.PDF.

Bouchama A, Aziz MA, Mahri SA, Gabere MN, Dlamy MA, Mohammad S, Abbad MA, Hussein M (2017) A model of exposure to extreme environmental heat uncovers the human transcriptome to heat stress. Sci Rep 7(1):9429

Breen CF, Goldstein JR (2022) Berkeley unified numident mortality database: public administrative records for individual-level mortality research. Demographic Res 47:111–142. https://doi.org/10.4054/DEMRES.2022.47.5.

Breen CF, Osborne M (2022) An assessment of CenSoc match quality. https://doi.org/10.31235/OSF.IO/BJ5MD.

Breen CF, Osborne M, Goldstein JR (2023) CenSoc: Public linked administrative mortality Records for individual-level research. Sci Data 10(1):1–12. https://doi.org/10.1038/s41597-023-02713-y.

Bruckner TA, van den Berg GJ, Smith KR, Catalano RA (2014) Ambient temperature during gestation and cold-related adult mortality in a Swedish cohort, 1915-2002. Soc Sci Med 119:191–197. https://doi.org/10.1016/J.SOCSCIMED.2014.01.049.

Burzyński M, Docquier F, Scheewel H (2021) The geography of climate migration. J Demogr Economics 87(3):345–381. https://doi.org/10.1017/DEM.2021.6.

Cadena BC, Kovak BK (2016) Immigrants equilibrate local labor markets: evidence from the great recession. Am Econ J: Appl Econ 8(1):257–290. https://doi.org/10.1257/APP.20140095.

Catalano RA, Bruckner TA, Smith KR, Saxton KB (2012) Temperature oscillations may shorten male lifespan via natural selection in utero. Clim Change 110(3–4):697–707. https://doi.org/10.1007/S10584-011-0119-4/METRICS.

Cattaneo C, Beine M, Fröhlich CJ, Kniveton D, Martinez-Zarzoso I, Mastrorillo M, Millock K, Piguet E, Schraven B (2019) Human migration in the era of climate change. Rev Environ Econ Policy 13(2):189–206. https://doi.org/10.1093/REEP/REZ008.

Cheng X, Su H (2010) Effects of climatic temperature stress on cardiovascular diseases. Eur J Intern Med 21(3):164–167

Chetty R, Stepner M, Abraham S, Lin S, Scuderi B, Turner N, Bergeron A, Cutler D (2016) The association between income and life expectancy in the United States, 2001-2014. JAMA 315(16):1750–1766. https://doi.org/10.1001/JAMA.2016.4226.

Cruz J-L, Rossi-Hansberg E (2023) The economic geography of global warming. Rev Econ Stud. https://doi.org/10.1093/RESTUD/RDAD042.

Damm AP (2009) Ethnic enclaves and immigrant labor market outcomes: quasi-experimental evidence 27(2):281–314. https://doi.org/10.1086/599336.

De Haas H, Czaika M, Flahaux M, Mahendra E, Natter K, Vezzoli S, Villares-Varela M (2019) International migration: trends, determinants, and policy effects. Popul Dev Rev 45(4):885–922

Deschênes O, Moretti E (2009) Extreme weather events, mortality, and migration. Rev Econ Stat 91(4):659–681. https://doi.org/10.1162/REST.91.4.659.

Diaz CJ, Koning SM, Martinez-Donate AP (2016) Moving beyond salmon bias: Mexican return migration and health selection. Demography 53:2005–2030

Fafchamps M, Shilpi F (2013) Determinants of the choice of migration Destination*. Oxf Bull Econ Stat 75(3):388–409. https://doi.org/10.1111/J.1468-0084.2012.00706.X.

Fletcher JM (2012) The effects of first occupation on long term health status: evidence from the Wisconsin longitudinal study. J Labor Res 33(1):49–75. https://doi.org/10.1007/S12122-011-9121-X/TABLES/13.

Fletcher JM (2015) New evidence of the effects of education on health in the US: compulsory schooling laws revisited. Soc Sci Med 127:101–107. https://doi.org/10.1016/J.SOCSCIMED.2014.09.052.

Fletcher JM, Noghanibehambari H (2022) Toxified to the Bone: early-life and childhood exposure to Lead and Men's old-age mortality. Working paper

Frey W (2023) New census projections show immigration is essential to the growth and vitality of a more diverse US population| brookings. Brookings Reports. https://www.brookings.edu/articles/new-census-projections-show-immigration-is-essential-to-the-growth-and-vitality-of-a-more-diverse-us-population/

Gill F (2019) Do enclaves help or hinder the American Dream? J Econ Issues 53(1):39–56. https://doi.org/10.1080/00213624.2019.1557000.

Gluckman PD, Hanson MA (2006) The developmental origins of health and disease. Early Life Origins Of Health And Disease 1–7. https://doi.org/10.1007/0-387-32632-4_1.

Gluckman PD, Hanson MA, Buklijas T (2010) A conceptual framework for the developmental origins of health and disease. J Dev Orig Health Dis 1(1):6–18. https://doi.org/10.1017/S2040174409990171.

Godfrey KM, Lillycrop KA, Burdge GC, Gluckman PD, Hanson MA (2007) Epigenetic mechanisms and the mismatch concept of the developmental origins of health and disease. Pediatr Res 61(7):5–10. https://doi.org/10.1203/pdr.0b013e318045bedb.

Goldstein JR, Alexander M, Breen C, Miranda González A, Menares F, Osborne M, Snyder M, Yildirim U (2021) Censoc Project. In: CenSoc mortality file: version 2.0. *University of California*, *Berkeley*. https://censoc.berkeley.edu/data/

Hayward AD, Lummaa V (2013) Testing the evolutionary basis of the predictive adaptive response hypothesis in a preindustrial human population. Evol, Med, And Public Health 2013(1):106. https://doi.org/10.1093/EMPH/EOT007.

Heutel G, Miller NH, Molitor D (2021) Adaptation and the mortality effects of temperature across U.S. Climate regions. Rev Econ Stat 103(4):740–753. https://doi.org/10.1162/REST_A_00936.

Kniesner TJ, Viscusi WK (2019) The value of a statistical life. Oxf Res Encycl Econ Finance. https://doi.org/10.1093/ACREFORE/9780190625979.013.138.

Koletzko B, Brands B, Poston L, Godfrey K, Demmelmair H (2012) Early nutrition programming of long-term health. Proc Nutr Soc 71(3):371–378. https://doi.org/10.1017/S0029665112000596.

Lleras-Muney A (2005) The relationship between education and adult mortality in the United States. Rev Econ Stud 72(1):189–221. https://doi.org/10.1111/0034-6527.00329.

Mäkinen TM, Juvonen R, Jokelainen J, Harju TH, Peitso A, Bloigu A, Silvennoinen-Kassinen S, Leinonen M, Hassi J (2009) Cold temperature and low humidity are associated with increased occurrence of respiratory tract infections. Respir Med 103(3):456–462

Markides KS, Eschbach K (2005) Aging, migration, and mortality: current status of research on the Hispanic paradox. J Gerontol B Psychol Sci Soc Sci 60(Special_Issue_2):S68–S75

Mayer T, Zignago S (2011) Notes on CEPII's distances measures: the GeoDist database. SSRN Electron J. https://doi.org/10.2139/SSRN.1994531.

Modrek S, Roberts E, Warren JR, Rehkopf D (2022) Long-term effects of local-area new deal work relief in childhood on educational, economic, and health outcomes over the life course: evidence from the Wisconsin longitudinal study. Demography 59(4):1489–1516. https://doi.org/10.1215/00703370-10111856.

NOAA (2023) Global surface summary of the Day. https://www.ncei.noaa.gov/access/metadata/landing-page/bin/iso?id=gov.noaa.ncdc:C00516

Noghanibehambari H, Engelman M (2022) Social insurance programs and later-life mortality: evidence from new deal relief spending. J Health Econ 86. https://doi.org/10.1016/J.JHEALECO.2022.102690.

Noghanibehambari H, Fletcher J (2023) Long-term health benefits of occupational licensing: evidence from midwifery laws. J Health Econ 92:102807. https://doi.org/10.1016/J.JHEALECO.2023.102807.

Noghanibehambari H, Fletcher J (2024) Dust to feed, dust to Gray: the effect of in utero exposure to the dust bowl on old-age longevity. Demography. https://doi.org/10.1215/00703370-11140760.

Noghanibehambari H, Fletcher J, Schmitz L, Duque V, Gawai V (2024) Early-life economic conditions and old-age male mortality: evidence from historical county-level bank deposit data. J Popul Econ 37(1):1–33. https://doi.org/10.1007/S00148-024-01007-W/TABLES/7.

Obolensky M, Tabellini M, Taylor C (2024) Homeward bound: how migrants seek out familiar climates. NBER working paper. https://doi.org/10.3386/W32035.

OECD (2024) International migration outlook 2024. OECD Publishing. https://doi.org/10.1787/50b0353e-en.

Osborne M (2023) CenSoc-numident and CenSoc-DMF weights manual

Osypuk TL, Diez Roux AV, Hadley C, Kandula NR (2009) Are immigrant enclaves healthy places to live? The multi-ethnic study of atherosclerosis. Soc Sci Med 69(1):110–120. https://doi.org/10.1016/J.SOCSCIMED.2009.04.010.

Pan A, Sun Q, Okereke OI, Rexrode KM, Hu FB (2011) Depression and risk of stroke morbidity and mortality: a meta-analysis and systematic review. JAMA 306(11):1241–1249

Price J, Buckles K, Van Leeuwen J, Riley I (2021) Combining family history and machine learning to link historical records: the census tree data set. Explor Econ Hist 80:101391. https://doi.org/10.1016/J.EEH.2021.101391.

Qu Y, Zhang W, Boutelle A-YM, Ryan I, Deng X, Liu X, Lin S (2023) Associations between ambient extreme heat exposure and emergency department visits related to kidney disease. Am J Kidney Dis 81(5):507–516

Roser M, Arriagada P, Hasell J, Ritchie H, Ortiz-Ospina E (2023) Economic growth - data page: gDP per capita. https://ourworldindata.org/grapher/maddison-data-gdp-per-capita-in-2011us-slopechart

Ruggles S, Flood S, Goeken R, Grover J, Meyer E (2020) IPUMS USA: version 10.0 [dataset]. *IPUMS*, *Minneapolis, MN*. https://doi.org/10.18128/D010.V10.0.

Samborska V (2024) How much have temperatures risen in countries across the world? Our World In Data

Shor E, Roelfs D (2019) Climate shock: moving to colder climates and immigrant mortality. Soc Sci Med 235:112397. https://doi.org/10.1016/J.SOCSCIMED.2019.112397.

Steckel RH (1983) The economic foundations of East-West migration during the 19th century. Explor Econ Hist 20(1):14–36. https://doi.org/10.1016/0014-4983(83)90040-2.

U.S. Census Bureau (2023) Income in the United States: 2022. https://www.census.gov/library/publications/2023/demo/p60-279.html

Vaiserman A (2021) Season-of-birth phenomenon in health and longevity: epidemiologic evidence and mechanistic considerations. J Dev Orig Health Dis 12(6):849–858. https://doi.org/10.1017/S2040174420001221.

Xuan LTT, Egondi T, Ngoan LT, Toan DTT, Huong LT (2014) Seasonality in mortality and its relationship to temperature among the older population in Hanoi, Vietnam. Glob Health Action 7(1). https://doi.org/10.3402/GHA.V7.23115.