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A Comparative Analysis of Life Tables: Examining Demographic Disparities between Black and White Populations in the USA (2000-2020)

Executive Summary

Disparities between Black and White populations in the USA are deeply rooted in historical and socioeconomic contexts. This research project conducts a thorough comparative analysis of life tables from 2000 to 2020, confirming persistent demographic disparities between Black and White populations in the United States. Noteworthy findings include distinct mortality trends, a diminishing life expectancy gap, and the impact of the pandemic, particularly on Black males. Age-specific and regional analyses emphasize the need for targeted interventions. The Lee-Carter model indicates positive mortality trends for Black populations, forecasting a gradual reduction in the life expectancy gap, expected to fully close after 2060.

Purpose and Objective - Research Question

The purpose of this study is to conduct a comparative analysis of life tables to examine demographic disparities between Black and White populations in the USA from 2000 to 2020.

Research Question(s):

- How have demographic indicators, as reflected in life tables, evolved differently for Black and White populations in the United States over the period 2000-2020?
- What factors may contribute to any observed disparities?

Relevance

The research project holds substantial relevance across multiple domains, significantly impacting economic planning, health, pensions, insurance, and broader societal well-being in USA. By investigating demographic disparities through life tables, the study offers critical insights into health inequalities between Black and White populations.

This knowledge is important for healthcare planning, enabling targeted interventions and resource allocation to address specific health challenges within each community. Moreover, the findings contribute to the formulation of effective public health policies and intervention strategies, ensuring equitable outcomes. Beyond any specific sector, the research serves as a foundation for advocating social equity, influencing policy initiatives aimed at addressing systemic inequalities in healthcare, employment, and

social services. Ultimately, the long-term societal impact of this study lies in fostering inclusivity, reducing disparities, and contributing to a healthier and more equitable future.

Socio-economic characteristics of the populations under study

Population (demographic characteristics)

In 2021 there were an estimated 331.9 million people in United states, by which 40.1 million were non-Hispanic black[1], which represents 12.1% of the total population of the country. Blacks/African Americans are the second largest minority population in the United States, following the Hispanic/Latino population (19%). The age pyramid of the country reflects a structure that included a significant proportion of the population in the middle-aged and older age groups.

Figure 1. USA age population pyramid, 2021, in percentage
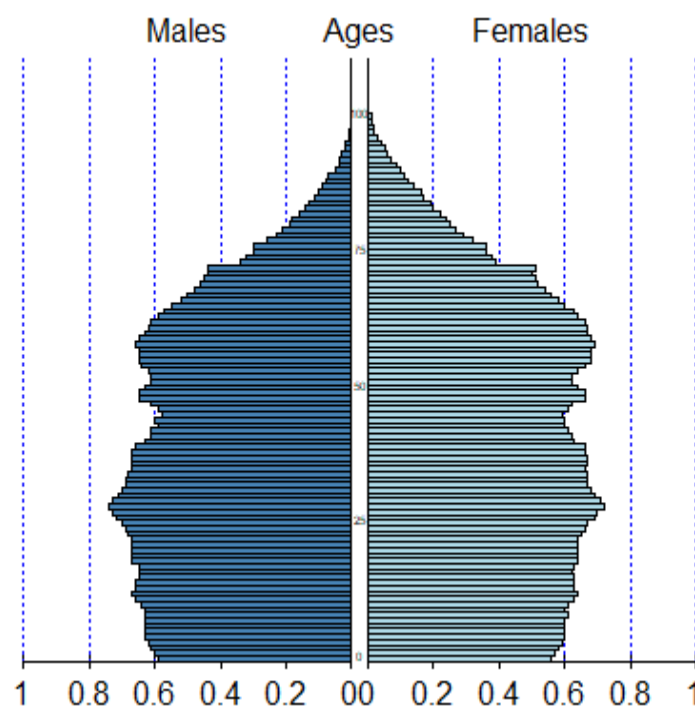
Source: *Elaborated with data from the human mortality data base 2021.*

In terms of growth, the USA total population has increased a 17.53% since 2000 (World Bank, 2021) while the black population marks a 30% increase since 2000, when there were 36.3 million Black people living in the U.S.

Regionally, the Southern region of the United States boasted the highest concentration of Black residents, with over half (56%) of the Black population residing there. Subsequently, the Midwest and Northeast regions each accounted for 17%, while the West housed 10%. In terms of individual states, Texas emerged as the state with the largest Black population, hosting approximately 4.0 million Black residents. Florida closely followed, securing the second position with 3.8 million, and Georgia claimed the third spot with 3.6 million. (pew research center 2021).

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[1] According to the standards on race and ethnicity set by the U.S. Office of Management and Budget (OMB) in 1997, a Black, non-Hispanic is a person having origins in any of the black racial groups of Africa except those of Hispanic origin. For census purposes are the people that self-identifies as black and not as a Hispanic.

Regarding population structure, nearly half (49%) of the Black population in the United States was under the age of 34. A comparable proportion (38%) fell within the 35 to 64 age brackets, while only 13% were aged 65 and above (in contrast to the 38% of the White population under 34 and 22% above 64). The overall fertility rate for every 1,000 Black females aged 15 to 44 was 60.2 during the 2019-2020 period, whereas the corresponding rate for white women stood at 54.4. These figures indicate a younger age distribution among Black individuals compared to Whites, with slightly higher fertility rates observed among Black women. (Moslimani, 2023)

**Figure 2**. Black and White Population proportion by age group, 2021.
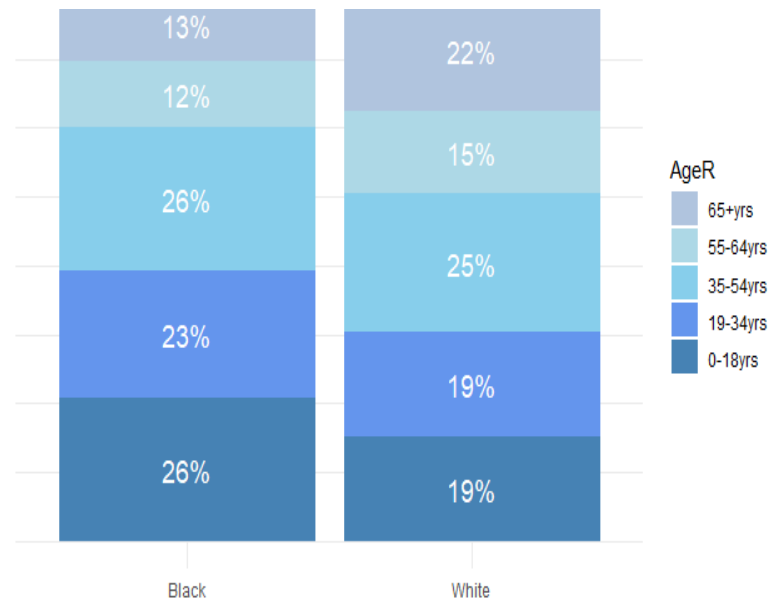
Source: *Elaborated with data from the pew research center 2021.*

Income and poverty

The United States boasts a highly diverse and dynamic economy, considered one of the largest and most influential globally. With a GDP consistently ranking among the highest in the world (25 trillion dollars in 2021), the United States is driven by a market-oriented approach, emphasizing private enterprise and entrepreneurship. They have a 76,291 dollars GDP per capita in 2021, fifth place in the OCDE[2].

**Figure 3**. OECD members according to their GDP per capita, 2021.
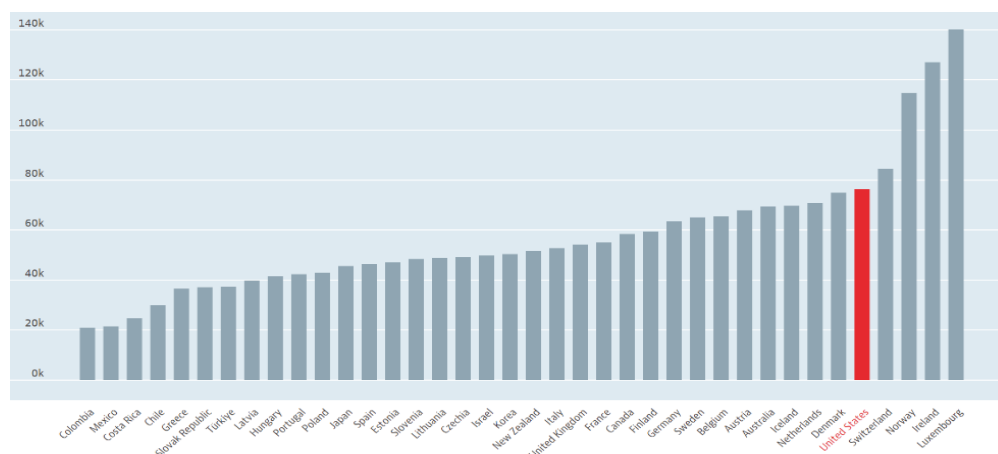
Source: *Aggregate National Accounts, SNA 2008 (or SNA 1993): Gross domestic product. OECD*

Concerning household incomes, as reported by the Census Bureau in 2021, the average median household income across the United States was $74,580. A notable disparity exists when comparing non-Hispanic Black households, with a median income of $48,297, to non-Hispanic White households, which reported a higher median income of $77,999. Moreover, the Census Bureau's 2021 data revealed that 19.5% of non-Hispanic Black households were living at the poverty level, whereas the corresponding figure for non-Hispanic White households was 8%. These statistics underscore a significant income disparity between the two racial groups. [3]

Figure 4. Average median income of Black population, 2021, percentage groups

Less than $25,000	$25,000-$49,999	$50,000-$74,999	$75,000-$99,999	$100,000+
29%	24	17	11	20
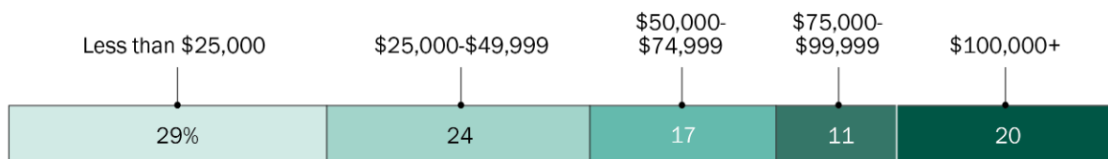
**Source:** Pew Research Center tabulations of the 2021 American Community Survey (IPUMS).

The 2021 poverty data in the United States reveals stark disparities, notably with the black ethnicity group experiencing the highest proportion of poverty among all ethnicities. The poverty rate for black individuals stands at 19.5%, notably higher than the 8.1% for white individuals. The ratio of the poverty population to the total population reveals a 1.7 times higher prevalence for black individuals compared to whites. (Census Bureau, 2021)

Figure 5. Percent of People in Poverty in USA by ethnicity, 2021
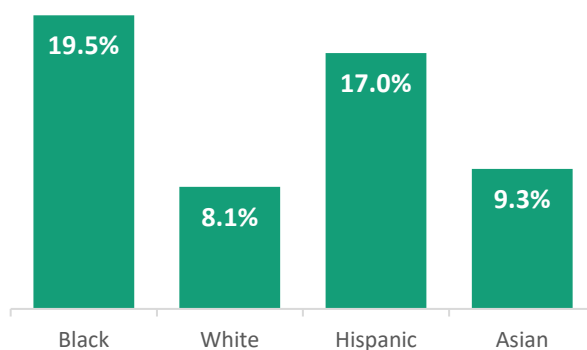
Source: *Elaborated with data from Official Poverty Measure 2021, U.S. Census Bureau (Poverty in the United States:*

Figure 6. Ratio of poverty population to total population, 2021.
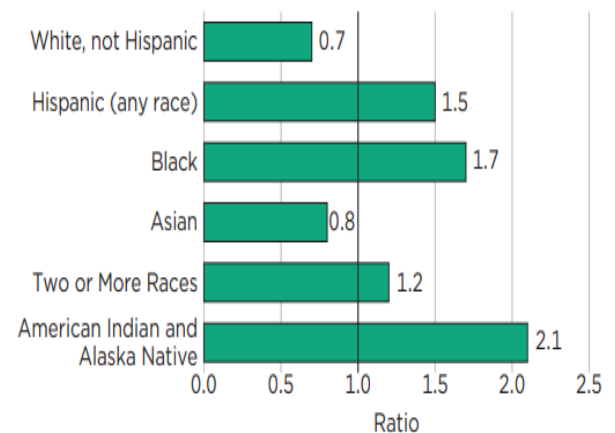
Source: *U.S. Census Bureau (Poverty in the United States: 2021)*

[3] U.S. CENSUS BUREAU. (2022, September). Poverty in the United States: 2021.
https://www.census.gov/content/dam/Census/library/publications/2022/demo/p60-277.pdf

Education

In 2021, educational attainment patterns reveal distinctions between non-Hispanic Black and non-Hispanic White populations aged 25 and over. A slightly smaller percentage of non-Hispanic Blacks (87.9%) had earned at least a high school diploma compared to their non-Hispanic White counterparts (93.5%) (OMH, 2021). Furthermore, there's a notable contrast in the attainment of bachelor's degrees or higher, with 24.7% of non-Hispanic Blacks achieving this level compared to 38.3% of non-Hispanic Whites. Notably, among non-Hispanic Blacks, a higher proportion of women (16.0%) attained at least a bachelor's degree compared to men (14.0%). In the non-Hispanic White population, a slightly higher proportion of women (23.5%) than men (23.2%) earned a bachelor's degree or higher. Additionally, 9.8% of non-Hispanic Blacks hold a graduate or advanced professional degree, contrasting with 15.0% in the non-Hispanic White population. [4]

Healthcare by ethnicity

Healthcare disparities between different ethnicity populations in the U.S. persist across various indicators. From 2010 to 2021, the uninsured rate among nonelderly black individuals (11%) exceeds that of whites (7%), but the wider disadvantage is for the Hispanic and Asian population with 20%. Additionally, Mental health services reveal a notable gap, with 48% of white individuals with any mental illness not receiving services, compared to more than 60% for the rest of ethnicities. Vaccination rates as of January 11, 2023,

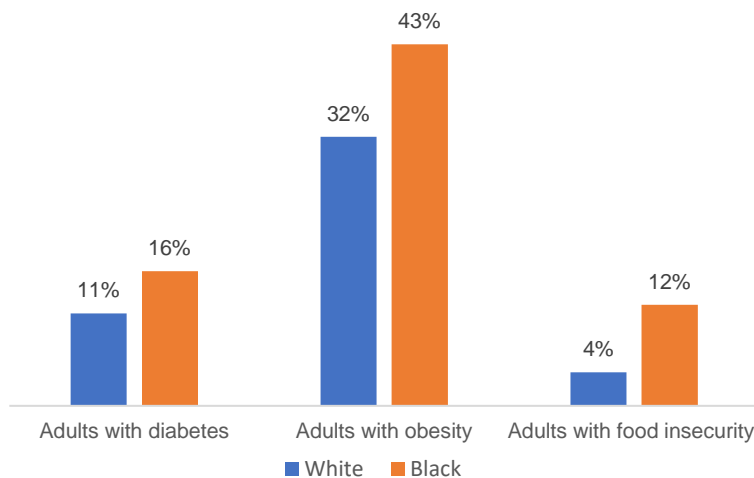**Figure 7.** Healthcare access indicators, 2021, in percentage.
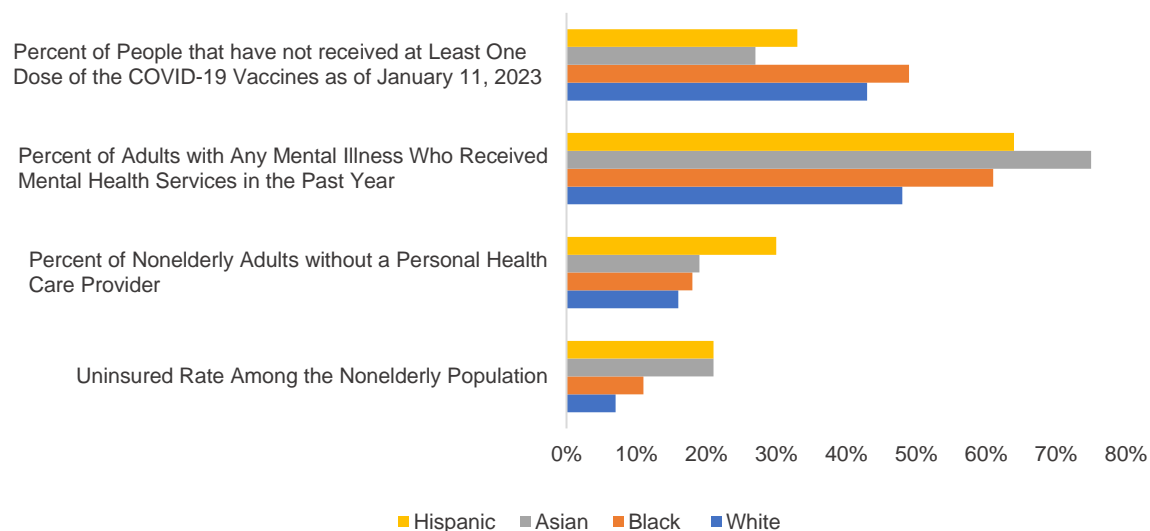
Source: *Key Data on Health and Health Care by Race and Ethnicity 2021.* https://www.kff.org/racial-equity-and-health-policy/report/key-data-on-health-and-health-care-by-race-and-ethnicity/

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[4] *Black/African American health*. (n.d.). Office of Minority Health. Retrieved January 3, 2024, from https://minorityhealth.hhs.gov/blackafrican-american-health.

indicate that 49% of black individuals have not received at least one dose of the COVID-19 vaccine, surpassing the 43% among whites.

Health disparities persist also in terms of infant health and malnutrition. Preterm births are higher among blacks compared to whites, and underweight conditions are more prevalent. Food insecurity affects black (13%) and Hispanic (11%) children over twice as much as white children (4%). Additionally, black infants are more than twice as likely to die as white infants (10.4 vs. 4.4 per 1,000 births).

Figure 8. Infants' health indicators, 2021, in percentage

	White	Black
% preterm births	9%	15%
% Underweight births	7%	15%
% children with food insecure	4%	13%

Source: *Key Data on Health and Health Care by Race and Ethnicity 2021.* https://www.kff.org/racial-equity-and-health-policy/report/key-data-on-health-and-health-care-by-race-and-ethnicity/

Figure 9. Some chronic disease indicators, 2021, in percentage

Source: Elaborated from *Key Data on Health and Health Care by Race and Ethnicity 2021.* https://www.kff.org/racial-equity-and-health-policy/report/key-data-on-health-and-health-care-by-race-and-ethnicity/

Chronic diseases and lifestyle factors also present differences between black and white populations in the U.S. Black individuals have a higher percentage of adults with diabetes (16% vs. 11%), higher obesity rate (43% vs. 32%), and a higher proportion of people with food insecurity compared to whites.

And also, according to Office of Minority Health "1 in 3 deaths in the U.S. is because of cardiovascular diseases. While everyone is affected, African Americans are at a higher risk.

African Americans are much more likely to suffer from hypertension (high blood pressure), heart attacks and even strokes., Additionally the death rate for Blacks/African Americans is generally higher than whites for COVID-19, cancer, asthma, influenza and pneumonia, diabetes, HIV/AIDS, and homicide." [5]

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[5] *Black/African American health*. (n.d.). Office of Minority Health. Retrieved January 3, 2024, from https://minorityhealth.hhs.gov/blackafrican-american-health.

Historical framework

Historical Context of Socioeconomic Inequalities:

There is a bast literature[6] that points out the deep-rooted systematic racism and socioeconomic disparities between Whites and Blacks in the United States and how it has evolved over centuries. To comprehend the demographic and mortality disparities between Black and White populations in the USA, it is imperative to delve into this historical context of socioeconomic inequalities. The roots of these disparities extend back to the nation's inception, marked by the legacy of slavery, institutionalized racism, and discriminatory practices. The abolition of slavery in the 19th century did not dismantle deeply ingrained racial hierarchies, leading to the emergence of the Jim Crow era and systemic discrimination that persisted well into the 20th century. Here is a brief historical overview:

- **Slavery (1619-1865):** The United States was built on the forced labor of enslaved Africans. The exploitation of African labor laid the foundation for racial hierarchies and economic disparities.

- **Jim Crow Era (Late 19th to Mid-20th Century):** After the abolition of slavery, the South implemented Jim Crow laws, enforcing racial segregation and systemic discrimination against Black Americans. This era institutionalized racism, limiting access to education, employment, housing, and voting rights for Black individuals. [7]

- **Redlining and Housing Discrimination (1930s-1960s):** The federal government, through practices like redlining, systematically denied loans and mortgages to Black communities. Redlining designated certain neighborhoods as high-risk, making it difficult for Black families to secure housing loans and perpetuating segregation. This had long-lasting effects on wealth accumulation and homeownership. (Kendi, 2016). [8]

- **Civil Rights Movement (1950s-1960s):** The Civil Rights Movement sought to dismantle institutionalized racism and segregation. Landmark legislation, such as the Civil Rights Act of 1964 and the Voting Rights Act of 1965, aimed to eliminate discriminatory practices. However, the legacy of historical injustices persisted. (Kendi, 2016).

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[6] Numerous scholarly works, including Michelle Alexander's "The New Jim Crow", Kendi's *"Stamped from the beginning"* and Richard Rothstein's "The color of law" among others, show the deep-rooted systemic racism and socioeconomic disparities between Whites and Blacks in the United States

[7] Alexander, M. (2010). *The new Jim Crow: Mass incarceration in the age of colorblindness.* The New Press.

[8] Kendi, I. X. (2016). *Stamped from the beginning: The definitive history of racist ideas in America*. Nation Books.)

- **Mass Incarceration and War on Drugs (1980s-1990s):** The War on Drugs disproportionately targeted Black communities, leading to mass incarceration. Strict drug laws and sentencing policies disproportionately affected Black individuals, contributing to the racial disparity in incarceration rates and creating a cycle of poverty and disenfranchisement.
- **Ongoing Discrimination and Systemic Racism:** Despite legal advances, systemic racism persists in various forms, including discriminatory policing practices, racial profiling, and socioeconomic disparities. The racial wealth gap remains significant, with Black households often having less wealth than their White counterparts.

These historical injustices laid the foundation for enduring socioeconomic gaps, influencing access to healthcare, education, employment, housing, and economic opportunities.

The historical socioeconomic disparities between Black and White populations have profound implications for health conditions. The context of these disparities has also influenced the epidemiological transition experienced by Black and White populations in the USA. The transition has been marked by inequality, with Black populations facing distinct challenges. The burden of infectious diseases, compounded by limited access to healthcare, has coexisted with a rising prevalence of chronic diseases. This unequal trajectory in epidemiological transition reflects the complex interplay between historical socioeconomic inequalities, healthcare access, and broader societal factors.[9] (Kendi, 2016).

Data and sources

This project uses data retrieved from the National Vital Statistics Reports provided by the Center for Disease Control and Prevention (CDC) of the United States, segregated by ethnicity and gender for the years 2000 to 2020.

To ensure uniformity and comparability, the initial dataset was structured and transformed into standardized complete life tables by the Human Life-Table project formatted from 0 to 100 years with a one-year interval.

The chosen period, 2000-2020, was selected due to the absence of ethnicity-disaggregated life tables preceding this timeframe or inconsistencies in data definitions for the Black population, which could make the comparisons inaccurate. Regarding the classification of ethnicity, the categories "Non-Hispanic black population" and "Non-Hispanic black population" were used for black and white groups,

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[9] Kendi, I. X. (2016). *Stamped from the beginning: The definitive history of racist ideas in America*. Nation Books.)

respectively. This classification is based on the standards on race and ethnicity set by the U.S. Office of Management and Budget (OMB).

Methods

This research undertook a comparative examination of the White and Black populations in the USA in the years 2000 to 2020, also incorporating the analysis of gender distinctions. Using the statistical software R, specially it's "Demography" package, the life tables of each group were compared, focusing on key variables such as mortality rate, survival, and life expectancy, mainly in the last year available. A detailed exploration of demographic disparities was run through a life expectancy at birth decomposition by age.

Complementing these analyses, a Lee Carter model was employed, initially to statistically compare the distinctive parameters characterizing each population's behavior and subsequently to forecast life expectancy. This forecast aimed to illuminate future trends within each group, providing valuable insights into the demographic trajectories of both the White and Black populations. This model was selected because it was the better that balances complexity with the available data, which is relatively short (just 20 years).

The model and some of the comparisons excluded the year 2020 to prevent potential inconsistencies from the significant disruptions in vital statistics caused by the drastic impacts of the COVID-19 pandemic.

Results

Preliminary indicators

In the first instance, differences between the main indicators of the series can be observed in the following graphs.

Regarding death rates, we can observe that the values at the end of the graph (at older ages) converge to a similar rate. However, at the beginning, for both Black females and males, the rates are higher than their white counterparts, indicating higher infant mortality. Similarly, a significant difference peak can be noted in the age range of 18 to 35, where Black males exhibit the highest mortality rate.

Figure 10. Death Rates by race, 2019
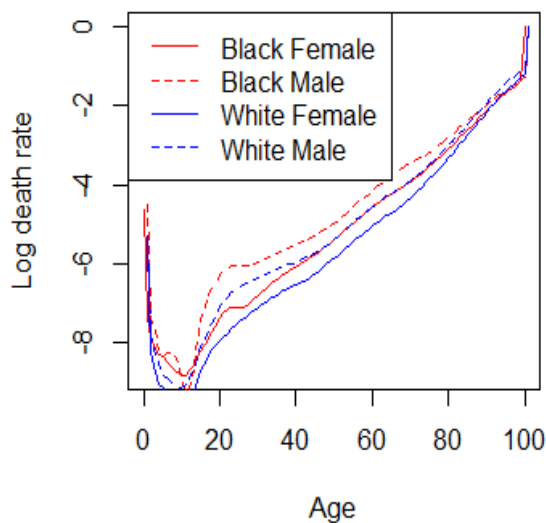
Source: Elaborated using data of the Human Life-table Project, 2019

A similar trend is evident in the survivorship graph (lx), where the phenomenon of "Rectangularization" is more pronounced in the White population, particularly among females. The "Rectangularization" phenomenon (characterized by a compression of mortality rates resulting in a survival curve that approaches a rectangular shape), reflects a more homogenous mortality among age groups in white population, were the most substantial difference is noticeable around the age of 60. The analysis of the deaths graph (dx) also provides interesting details. We can observe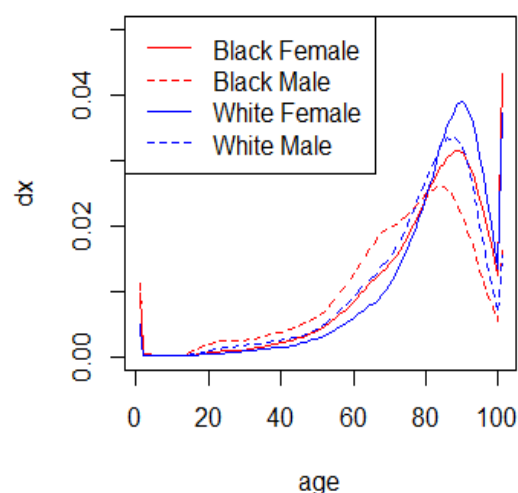 that Black males exhibit a peak in deaths around the age of 60, earlier than other population groups, which show an increase from the age of 80 onwards.

Figure 11. Survivors in USA by ethnicity, 2019
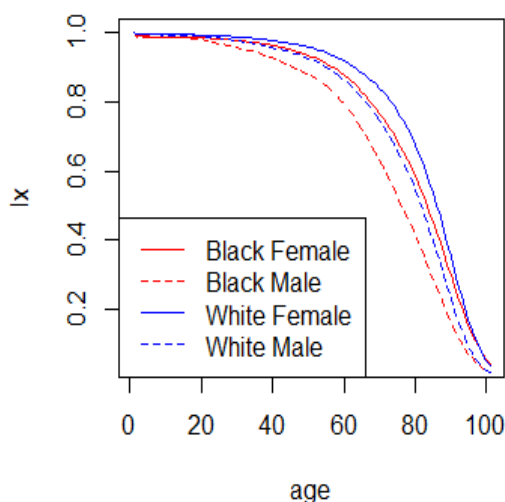
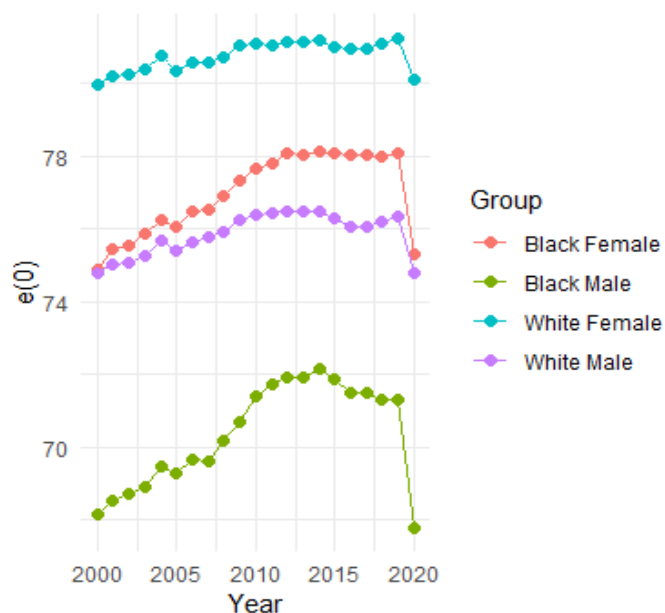**Figure 12.** Deaths in USA by ethnicity, 2019

Life expectancy at birth

Comparing the life expectancy series at birth for the available period allows for a clearer view of the expected differences in the previous indicators. The four population groups (black female, black male, white female, and white male) show a similar trend, which increases until the drastic decline in 2020 due to the pandemic. But the differences are evident in the scale of values and the growth rate in the years analyzed.

Firstly, it can be noted that the increase in life expectancy (the slope of the curve) has been greater in the black population, especially in males. Meanwhile, the white population has exhibited a more stable, almost constant, behavior, especially among women.

For instance, black men experienced an increase of almost four years in life expectancy before the pandemic-related decline (from 68 years to almost 72), while white men only had an increase of just over one year in life expectancy between 2000 and 2019. Similarly, black women increased by 3 years in the studied period, while white women increased by only 1.25 years.

Figure 13. Life expectancy at birth in USA, 2000-2020

But what stands out the most is the gap in values for both ethnic groups. Combining both sexes, the black population has 5.2 years less life expectancy than the white population in 2019, a difference that has been decreasing, since it was 6.5 years in 2000. In 2019, the group with the lowest life expectancy is black men with around 72 years, and the group with the highest is white women with 81 years.

Another important factor to mention is that the black population was more severely affected by the pandemic, in terms of life expectancy, than whites. The black ethnic group experienced a decline of 3.2 years in this indicator from 2019 to 2020 (largely attributed to the pandemic), while whites also suffered a decline, but only by 1.4 years. The most affected were specifically black men with a decline of 3.5 years.

To delve deeper into this life expectancy gap, we can decompose to see which age interval presents the greatest impact on the difference in life expectancy between whites and blacks.

Figure 14. Decomposition of e(0) differences by age: white vs black population, in USA, 2019.
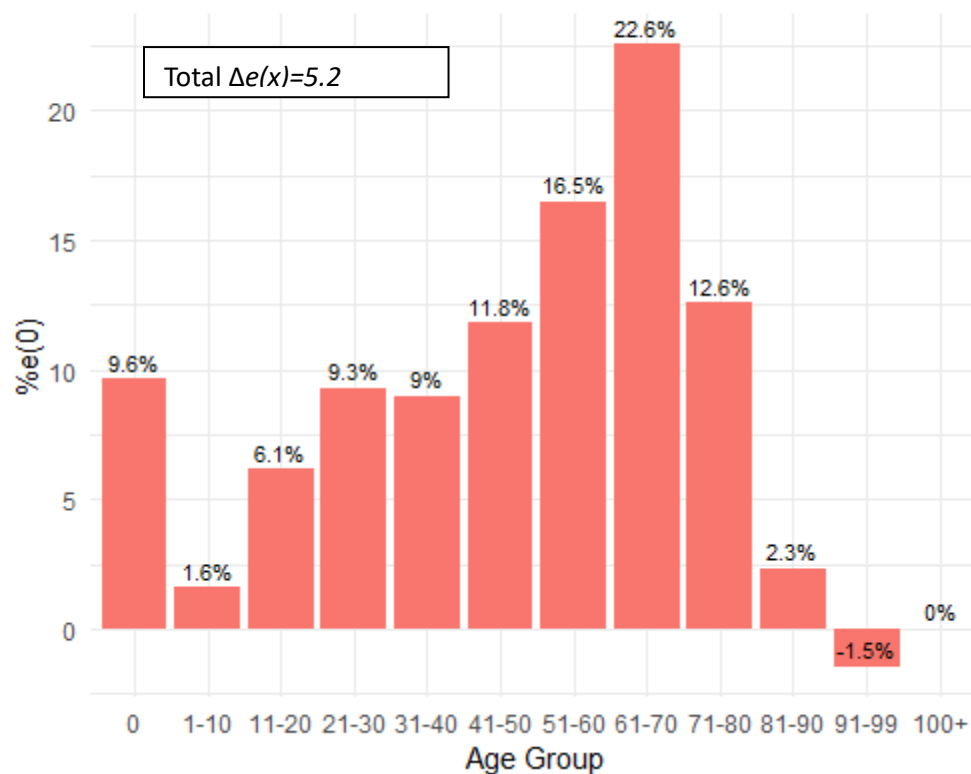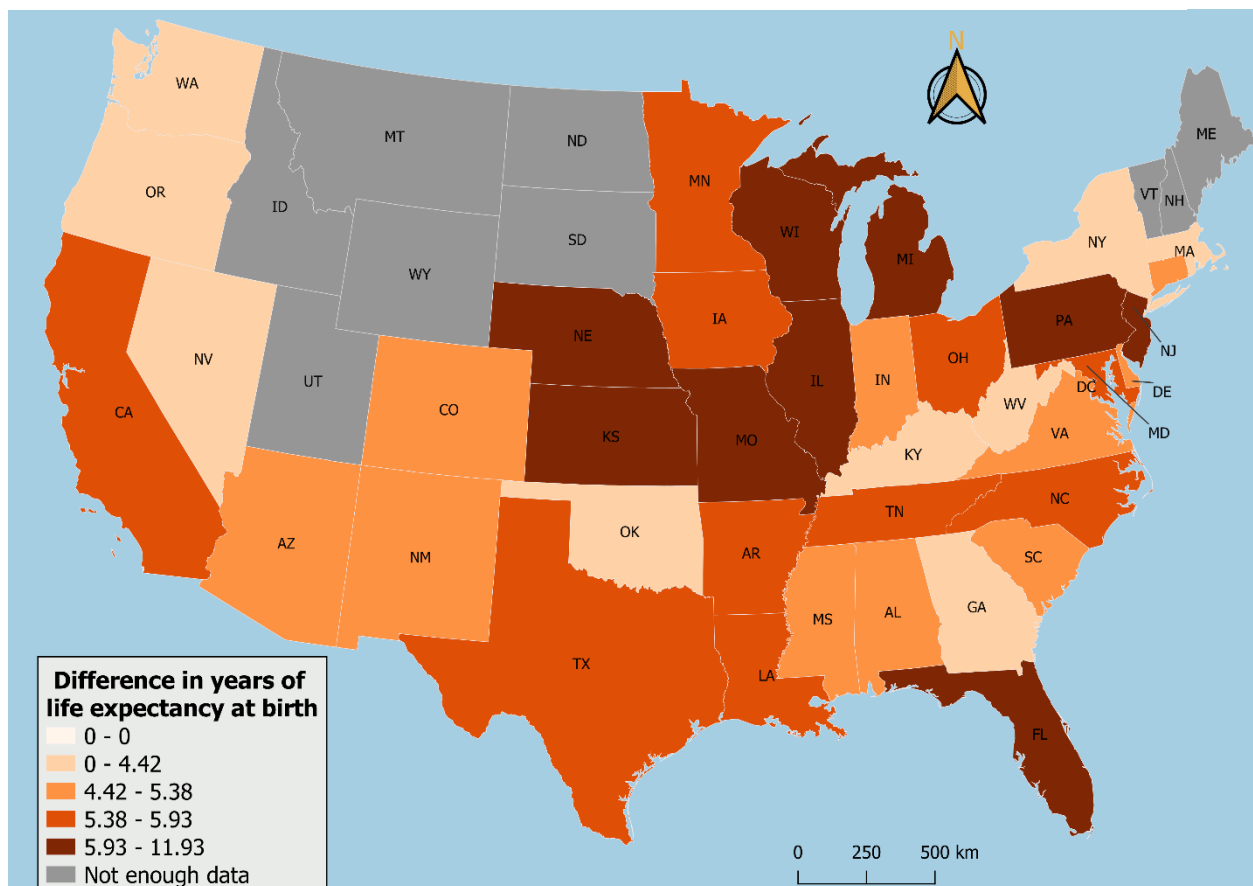
Among the key findings, the age group of 61-70 stands out with a significantly higher percentage for the black population, indicating a substantial impact on the overall life expectancy divergence. Both the 61-

70 group and the 51-60 group combined represent 39% of the difference in life expectancy. The impact in this age range could be related with interplay of factors influencing mortality, among these is possible to highlight the prevalence of chronic diseases and lifestyle habits.

Moreover, age groups 0-10, 11-20, and 31-40 also contribute substantially to the observed disparities, emphasizing the need for targeted interventions to address the underlying factors driving these variations.

Additionally, to expand the analysis. we can see that the previous differences in life expectancy are more predominant in some states than others.

Map 1. Difference in years of life expectancy at birth e(0) between White and Black population in USA by state, 2001

Looking at this map of 2001[10] data showing the e(0) difference between both groups, we can that the gap in life expectancy is not the same thought the country. Some states at the Midwest of USA and Florida shows a higher difference (more than 6 years) than the rest of states. This finding could be related with the distribution of black population across USA, as we saw that in the Midwest there is a relatively low concentration of black people compare to other regions. The state that shows the highest gap is the District of Columbia with a surprising 11.9 gap in life expectancy.

Lee-Carter model

To better analyze and forecast the specific components of series of mortality rates for the ethnic groups, a statistical model was performed. Given that the series is relatively short (20 years), it was essential to choose a model that balances complexity with the available data. a Lee-Carter model was selected because is simple and might be more suitable for shorter time series to avoid overfitting.

The lee carter model is composed of the logarithm of the mortality rates (mx) as the depended variable, that is explain by 3 parameters. i) α : a constant term for age-pattern of mortality averaged over time (represent the long-trem trend). ii) K : An univariate mortality index describing the change in the mortality level over time (represent the deviations from the long-term trend for each time period), that has a interaction term for the age-specific impact . iii) ε : Error term with expected value equal to 0.

Figure 15. Lee-carter model theorical formulation

$$\ln m_x(t) = \alpha_x + \beta_x K_t + \varepsilon_{x,t}$$

Two identical models were performed, one for the Black group and one for the white group, the percentage variation explained by them were 75.5% and 73.5%, respectively. In this case the method of adjustment for the Kt was the Lee-Carter method, which is a random walk with drift. The corresponding analysis of the residuals for black and white populations models were performed, and in both cases the results showed a proper fit of the model[11], with a small exception in the last years (after 2015) of the black population model, were is possible to see some correlation between the residuals and time.

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[10] 2001 was the only year available why data for life expectancy by ethnicity and state.
[11] The graphs of residuals can be seen in the appendix section at the end.

Figure 16. Lee-carter model – ax Values Comparison
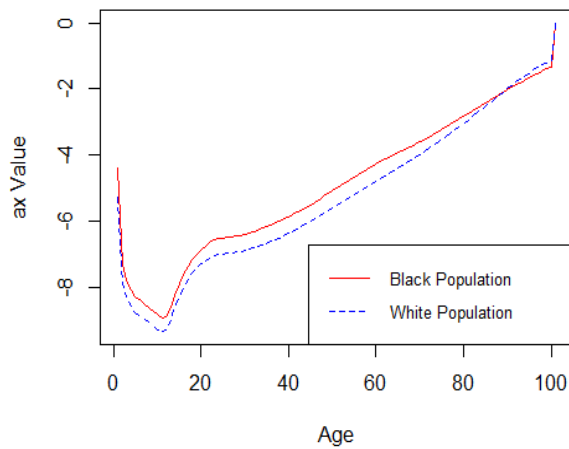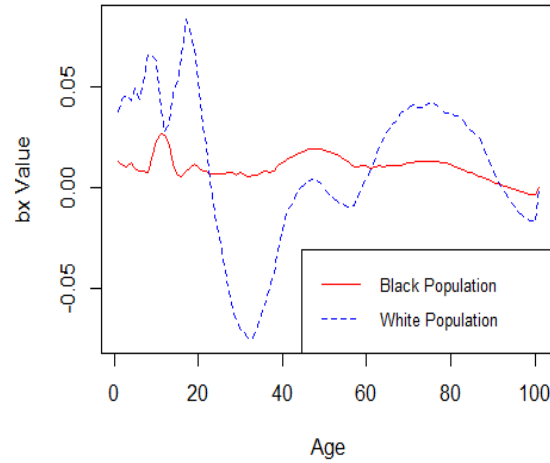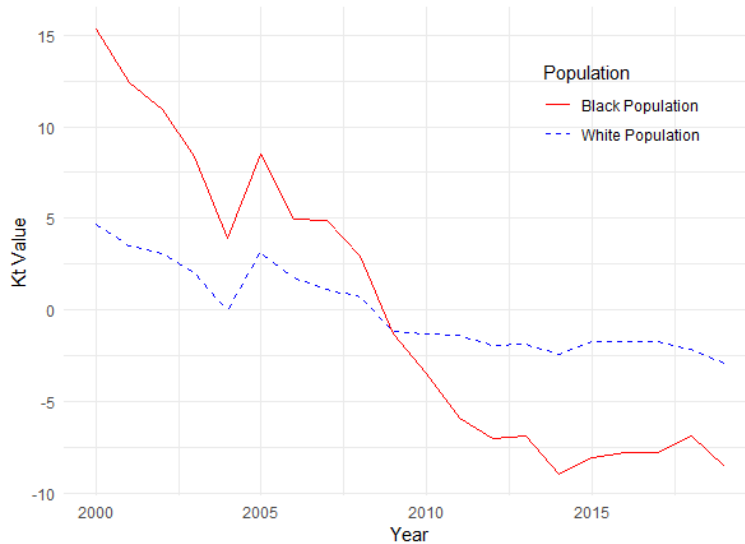

Figure 17. Lee-carter model – bx Values Comparison

Source: Elaborated using data of the Human Life-table Project, 2000-2019

The estimated values of the parameters agree with what we saw before. The α(x) values show a similar trend for both groups, denoting a similar long-term trend for black and White population. In other hand, the beta x (interaction term) values show a very different behavior. For black population is almost constant around cero across all ages while for whites it starts with positive values, then go to negative in the 20-40 age Interval and then goes up again. This pattern in the White population's βx values suggests a more complex age-specific effect on mortality, a non-linear age pattern with specific age intervals contributing differently to mortality variations.

Figure 18. Lee-carter model – Kt Values Comparison 2000-2019

Source: Elaborated using data of the Human Life-table Project, 2000-2019

The comparison of Kt values from the Lee-Carter models for the black and white populations reveals more intriguing patterns. The Kt values for the black population exhibit a notable decreasing trend from 2000 to

2019, indicative of significant improvements in mortality rates over this period. Starting at 15 in 2000 and finishing around -6 in 2019 underscores a positive shift in life expectancy. In contrast, the Kt values for the white population remain relatively stable around 0, suggesting a lack of significant overall trend in mortality rates during the same timeframe (As we saw in the life expectancy at birth graphs). The behavior of the two lines and the interception of them in 2009 suggest that the white population already converge to a certain "stable" level in terms of mortality, while the black population still have room for improvement.

Considering these findings, a pertinent question arises: Is it conceivable that the disparity in life expectancy between the white and black populations could diminish or eventually be eliminated in the long run? After running a 20 years forecast using the a random walk with drift (ARIMA(0, 1, 0)) from the Lee-Carter model, the answer is the following: Yes, but not soon.

The forecast indicates a clear trajectory towards a diminishing gap in life expectancy between the two groups, ultimately leading to complete closure. However, this transformation is not expected to materialize in the next few years. According to the projection, the difference in years of life expectancy is projected to decrease by 1.5 years in 2030, by 2.5 years by 2040, and is not anticipated to fully close until after 2060.

Figure 19. Past and forecast life expectancy in USA, 2000-2040
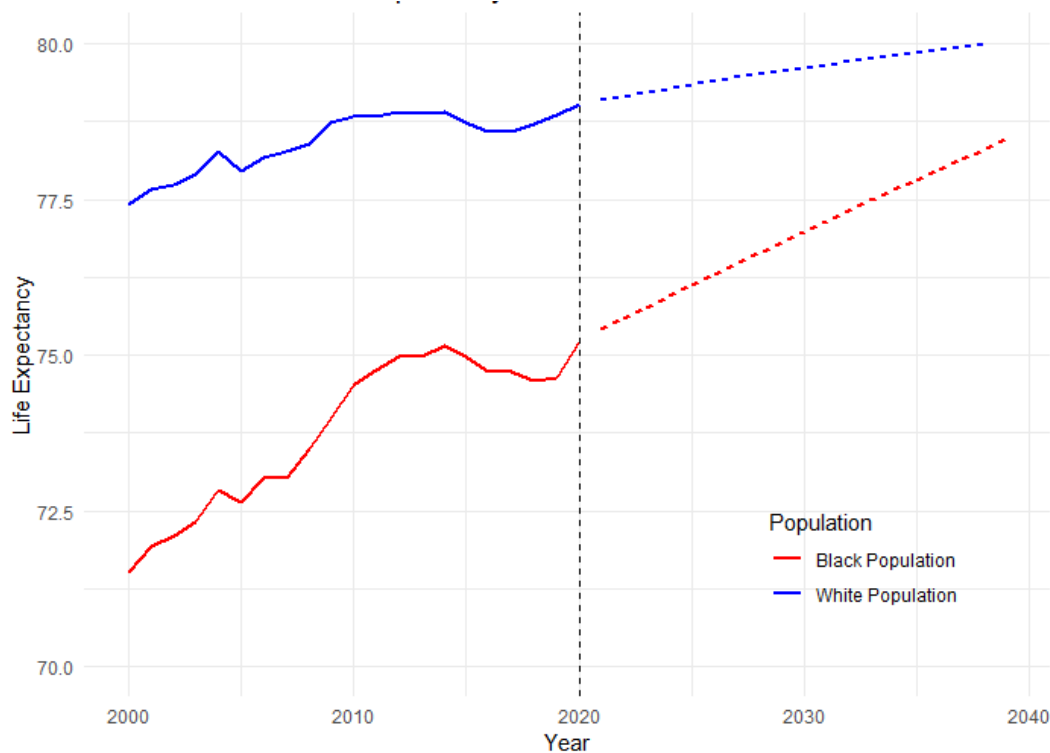
Conclusions

In summary, the comparative analysis of life tables spanning 2000 to 2020 unveils profound demographic disparities persisting between Black and White populations in the USA. Rooted in historical racial inequities, these disparities manifest in distinctive mortality trends. Notably, Black males exhibit higher infant mortality and a pronounced mortality peak at ages 18-35, emphasizing persistent challenges. The "Rectangularization" phenomenon highlights more homogeneous mortality rates among White females, that may underline complex historical and structural factors.

Life expectancy dynamics reveal a greater increase for Black populations, especially in males, however, there is still a consistent gap between the two racial groups, diminishing from 6.5 years in 2000 to 5.2 years in 2019. The pandemic exacerbates disparities, with Black men facing a substantial 3.5-year decline compared to 1.4 years for Whites. Age group analysis emphasizes the significance of the 51-70 age range, where chronic diseases and lifestyle habits play a crucial role. Geographic disparities underscore higher life expectancy gaps in the Midwest and Florida, with the District of Columbia exhibiting an alarming 11.9-year difference.

The Lee-Carter model indicates positive mortality trends for Black populations, suggesting potential convergence, while the forecast foresees a gradual reduction in the life expectancy gap, projecting complete closure after 2060. These findings underscore the urgent need for sustained efforts, targeted interventions, and improved healthcare access to dismantle deeply entrenched disparities and promote equitable demographic outcomes in the United States.
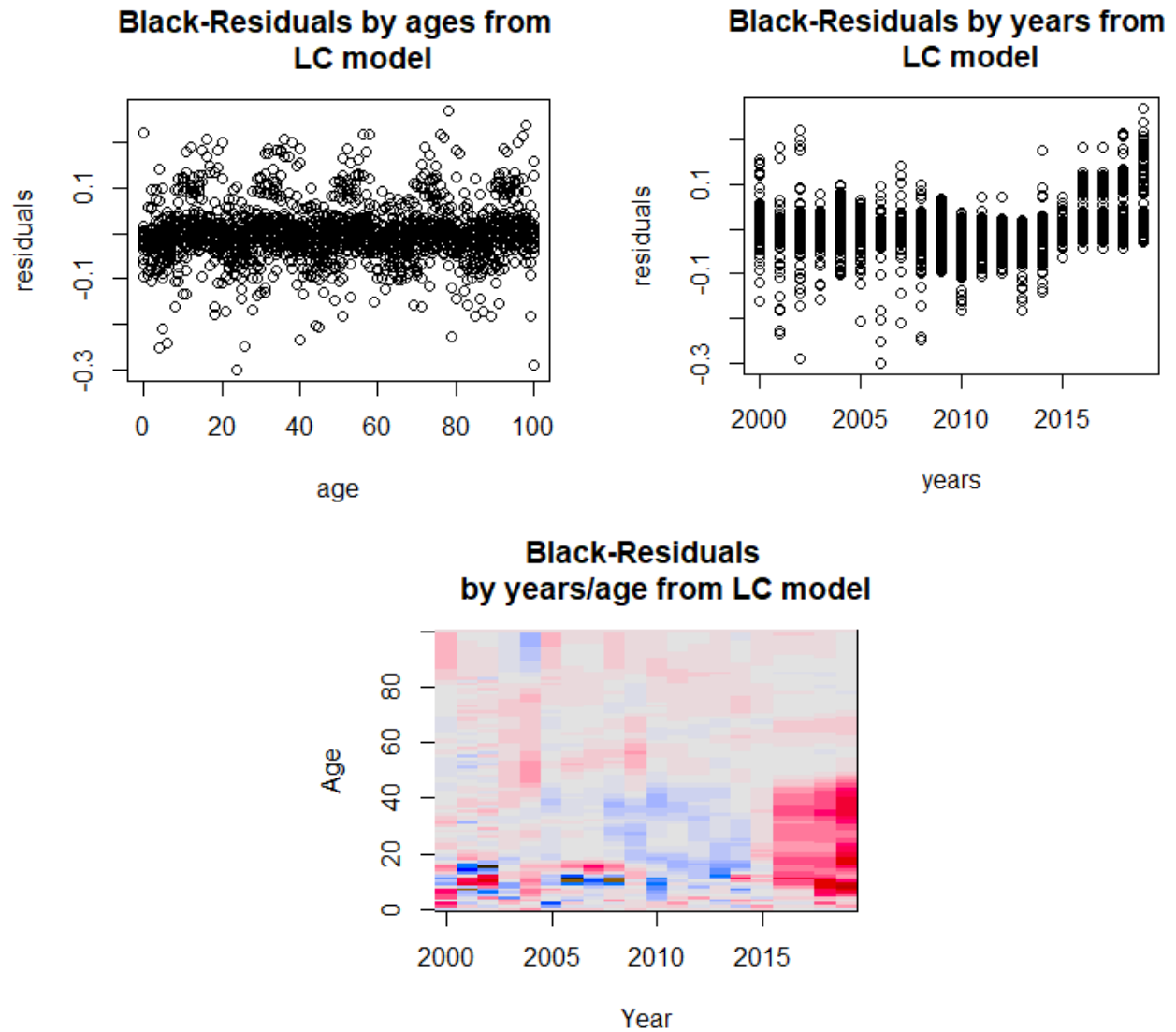
This study also opens avenues for further exploration and analysis. One promising alternative for future research is a more detailed investigation into the underlying factors contributing to disparities within specific age groups, particularly in the 61-70 range. Furthermore, a longitudinal analysis extending beyond 2020 could provide a more robust understanding of how recent events, beyond the pandemic, influence demographic trends.

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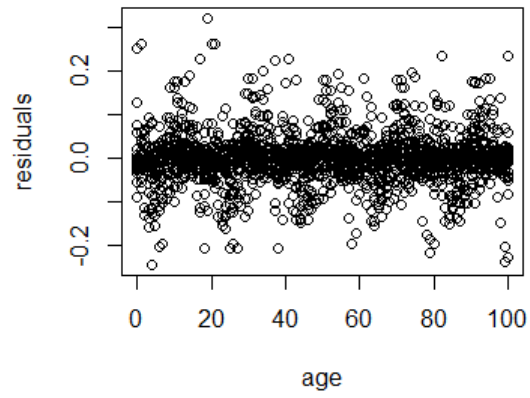
Appendix (Lee-Carter models residuals)

Black population

Black-Residuals by ages from LC model

Black-Residuals by years from LC model

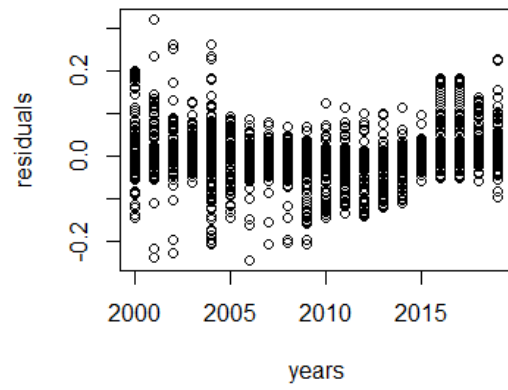### Black-Residuals by years/age from LC model

White population

White-Residuals by ages from LC model

White-Residuals by years from LC model

White-Residuals by years from LC model