# Life expectancy in the USA

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## Problem statement

How has life expectancy at birth changed in the USA since 1980? How has life expectancy varied between gender and race? Women typically outlive men. We are interested in exploring whether the difference is decreasing or increasing.

Life expectancy is a measure that is often used to gauge the overall health of a community. Life expectancy at birth measures health status across all age groups. Shifts in life expectancy are often used to describe trends in mortality. Being able to predict how populations will age has enormous implications for the planning and provision of services and support. Small increases in life expectancy translate into large increases in the population. As the life expectancy of a population lengthens, the number of people living with chronic illnesses tends to increase because chronic illnesses are more common among older persons.

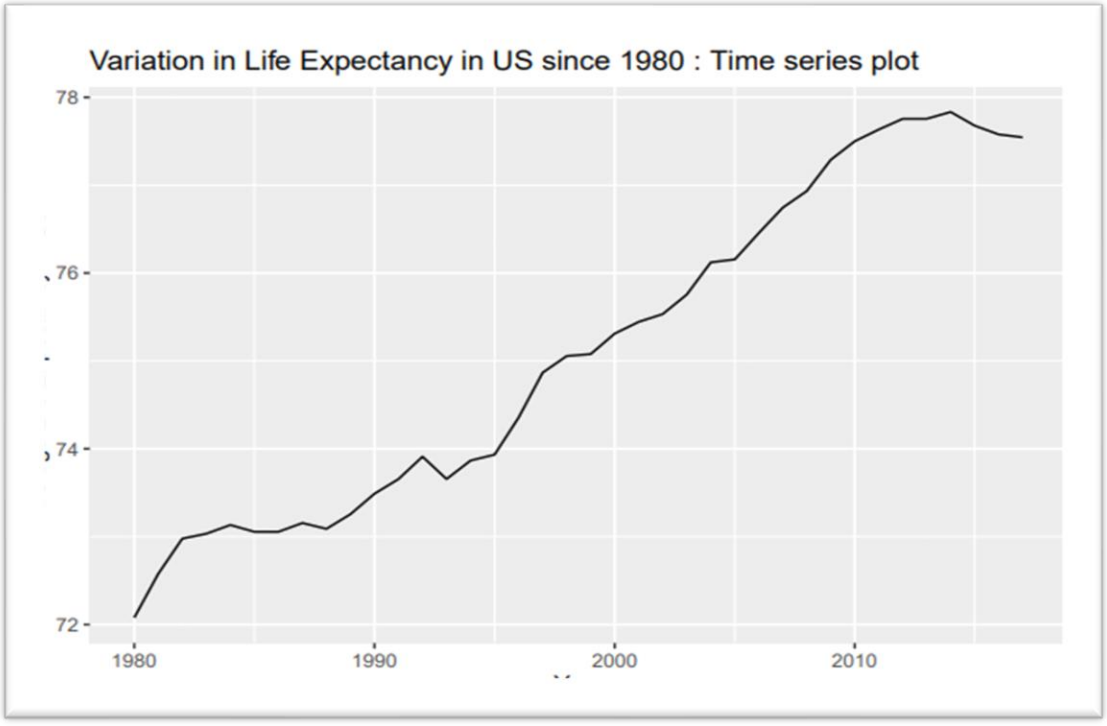
## Introduction

During the nineteenth and early twentieth centuries, an increase in life expectancy was driven mainly by improvements in sanitation, housing, and education, causing a steady decline in early and mid-life mortality, which was chiefly due to infections. We explore the changes in life expectancy in the United States from the 19th century. We wish to study various datasets related to life expectancy from the CDC(Centers for Disease Control and Prevention) , NCHS(The National Center for Health Statistics) and IHME(Institute for Health Metrics and Evaluation). The data consists of life expectancy from the 19th century upto 2014. The life expectancy in the data is the life expectancy only at birth. The life expectancy is given by gender, race and states. The NCHS data contains life expectancy from 1900-2014 and gives the information about life expectancy overtime. The CDC data contains life expectancy by race and gender. Lastly, we will use the IHME data to show how life expectancy varies by states and regions. We will also use the census data to get the population density of each state. The data does not include the latest as the information is only up to 2014 and also does not include state wise population of blacks and whites or gender, rather it includes population as a whole. Our main aim is to review how life expectancy is changing over the years and to perform an in-depth analysis by breaking down the search iteratively. We will see how life expectancy varies by state, region, sex, and race. And we will see whether there is a relationship between life expectancy and population density.

### Life expectancy over the years

We begin by examining how the average life expectancy at birth is changed from 1980. As expected the overall life expectancy has been continuously increasing till 2012 but dips after 2013. Since the data is a time-series data, we perform time series analysis to view the trend. Time series analysis is a statistical technique that deals with time-series data, or trend analysis. Time series data means that data is in a series of particular time periods or intervals.

**Figure 1**

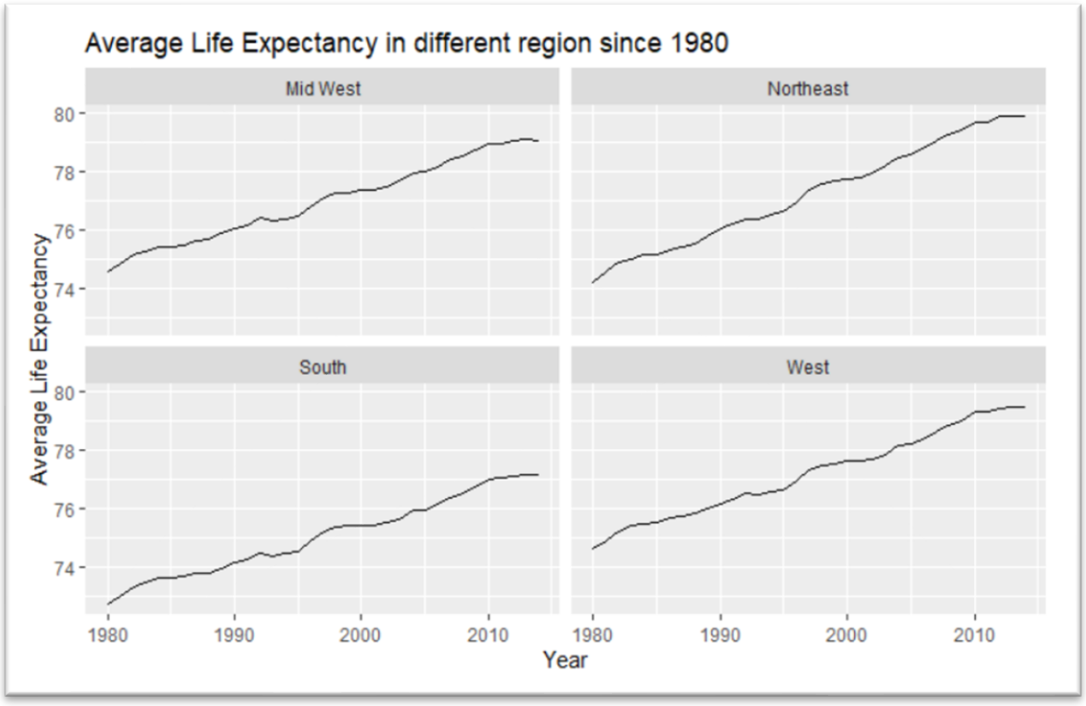


An interesting thing to see is the dip in life expectancy in 2013. Looking at the graph till 2010, it suggests that life expectancy will go on increasing which is certainly not possible. It is possible that humans might be reaching the peak of their life expectancy as the above graph suggests that life expectancy is plateauing.

Further, we see the trend of life expectancy for all 4 regions in the USA. We are interested in seeing whether all the regions follow a similar trend.

The overall trend of life expectancy is very similar in all regions and it seems that the average life expectancy in all regions is plateauing. From the above plot, we can see that overall region-wise, the highest increase in average life expectancy is for the Northeast region followed by the West region. The South region has the lowest increase in average life expectancy. This is consistent with the fact that the Northeast and West region has a better standard of living with high-income people living there. Hence, the life expectancy rate will be high in those regions.

**Figure 2**



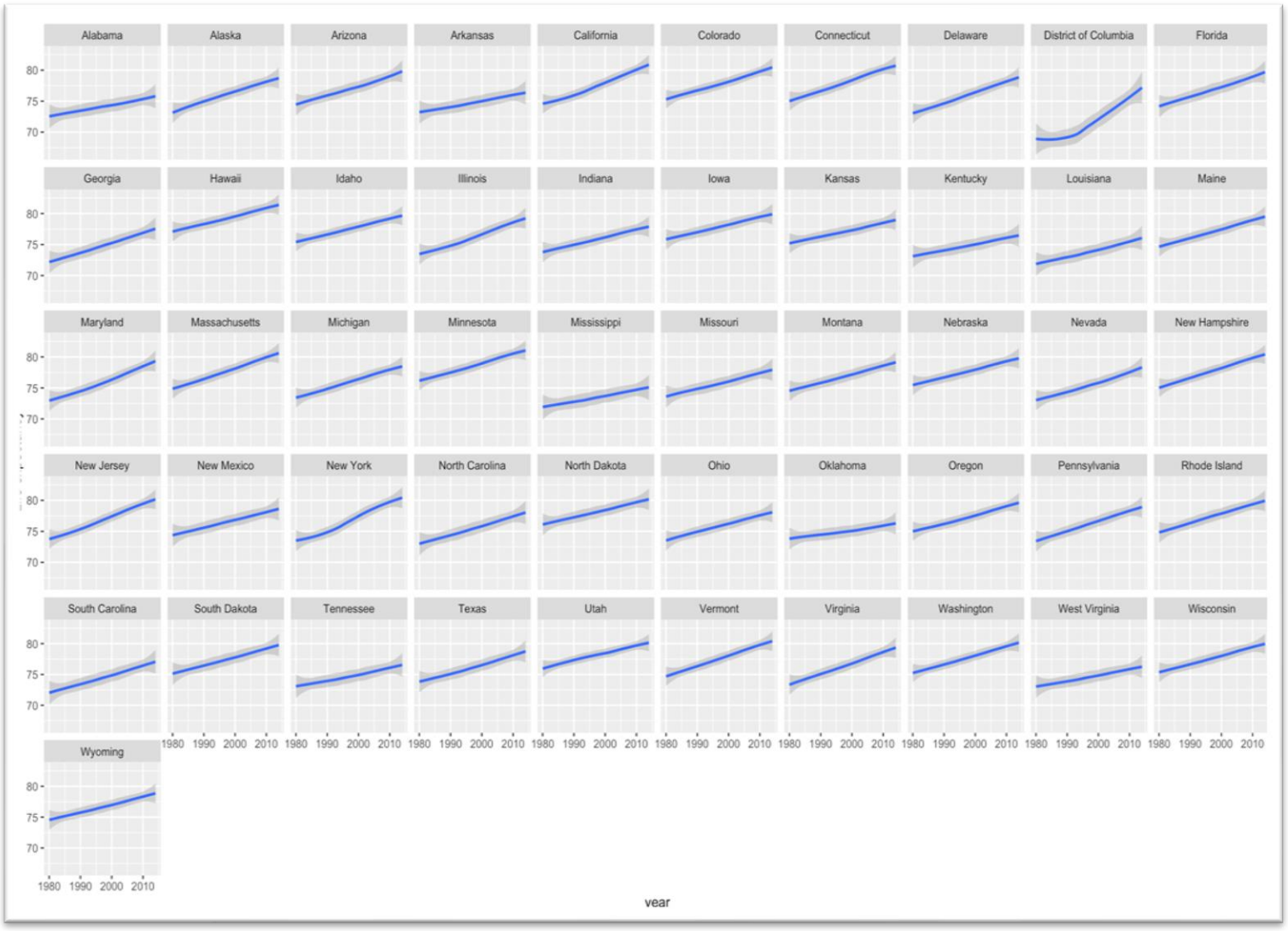

We further explore life expectancy in all the states(Fig 3). To observe the trend in all states we fit a loess model.

*Loess method: This is a nonparametric method because the linearity assumptions of conventional regression methods have been relaxed. The fitted points and their standard errors are estimated with respect to the whole curve rather than a particular estimate. So, the overall uncertainty is measured as to how well the estimated curve fits the population curve.*

The highest increase in average life expectancy in the West region since 1980 is observed in California with an average of approximately 82.5 in the current year. Alaska, Wyoming, New Mexico, and Nevada have the lowest increase in average life expectancy since 1980 with 79 in the current year.

It can be seen that many states have a very less increase in life expectancy since 1980.
The highest increase in life expectancy in the South region since 1980 is observed in Delaware, Florida, Maryland, and Virginia with approximately 80 in the current year. We can also observe that a state like Oklahoma has a flat curve varying from 73 - 76. The lowest average life expectancy in the current year is seen in Mississippi. Even though most states have an increased life expectancy, there are many states which show a flat line meaning there has not been much increase in life expectancy.

**Figure 3**



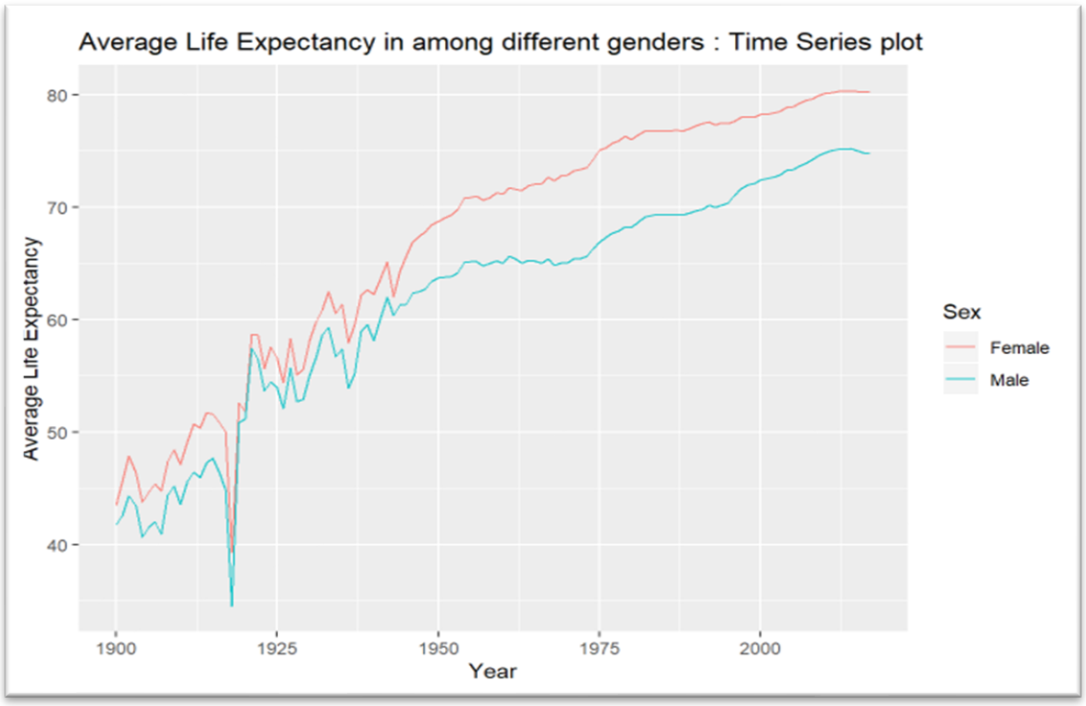

All the states in the Northeast region have pretty much the same distribution and highest in Connecticut (approx. 81 in the current year).

The highest increase in average life expectancy in the Midwest region(Figure 6) since 1980 is observed in Minnesota with approximately 81 in the current year. Also, Ohio, Indiana, and Missouri has the lowest increase in life expectancy with 77.5 in the current year. The overall change in life expectancy is the same for all regions and states i.e an increasing life expectancy over the years. Also, life expectancy in all states seems to have plateaued in 2013.

**Life expectancy over the years by sex and race**

We now see how life expectancy has varied by sex and race. For the race, we see the difference in life expectancy between blacks and whites. We begin by observing the average life expectancy for males and females over the year. Again we perform time series analysis and plot the time series data.

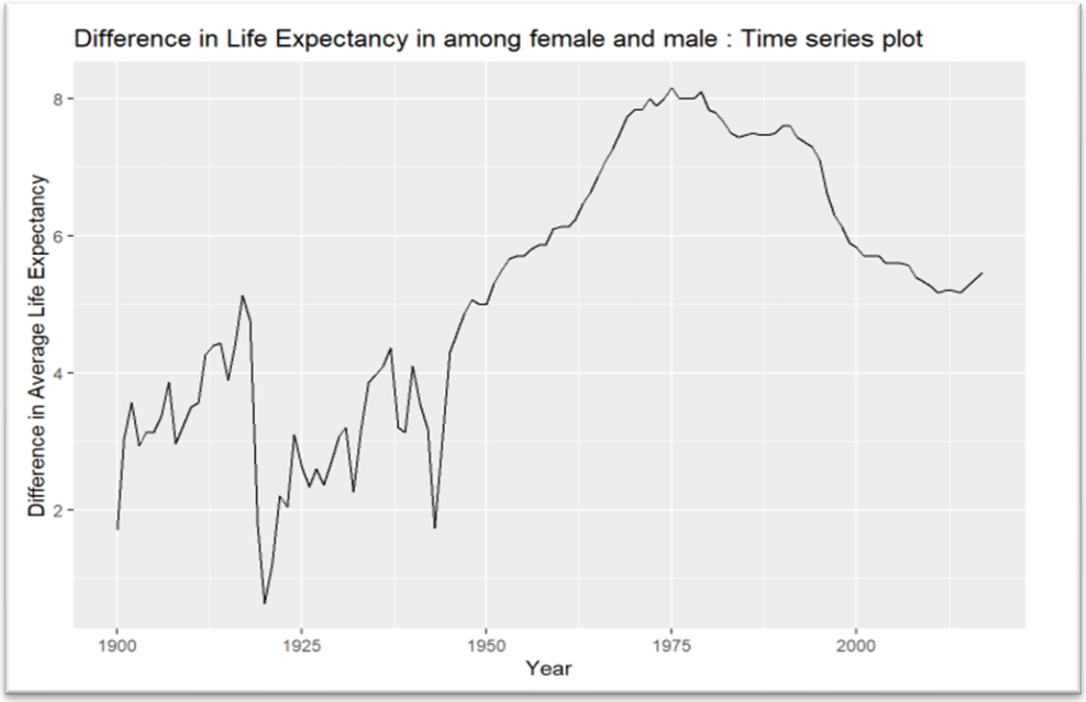
**Figure 4**




From the plot, we can observe that the overall average life expectancy of males and females is increasing over the years except there is a sudden dip in 1920. Life expectancy generally increased throughout the period of study (Fig. 4). However, it oscillated substantially throughout the 1920s and 1930s with important drops in 1923, 1926, 1928–1929, and 1936 coinciding with strong economic expansions. Also, we can see saturation in average life expectancy for both males and females from 2000 and expecting to be uniformly distributed from 2013 to the next subsequent years.

Further, we see how the gap in life expectancy has varied over the years for males and females (Fig. 5). The graph below shows the difference in life expectancy between males and females. The Y-axis shows the average age by which a female outlives a male.

**Figure 5**



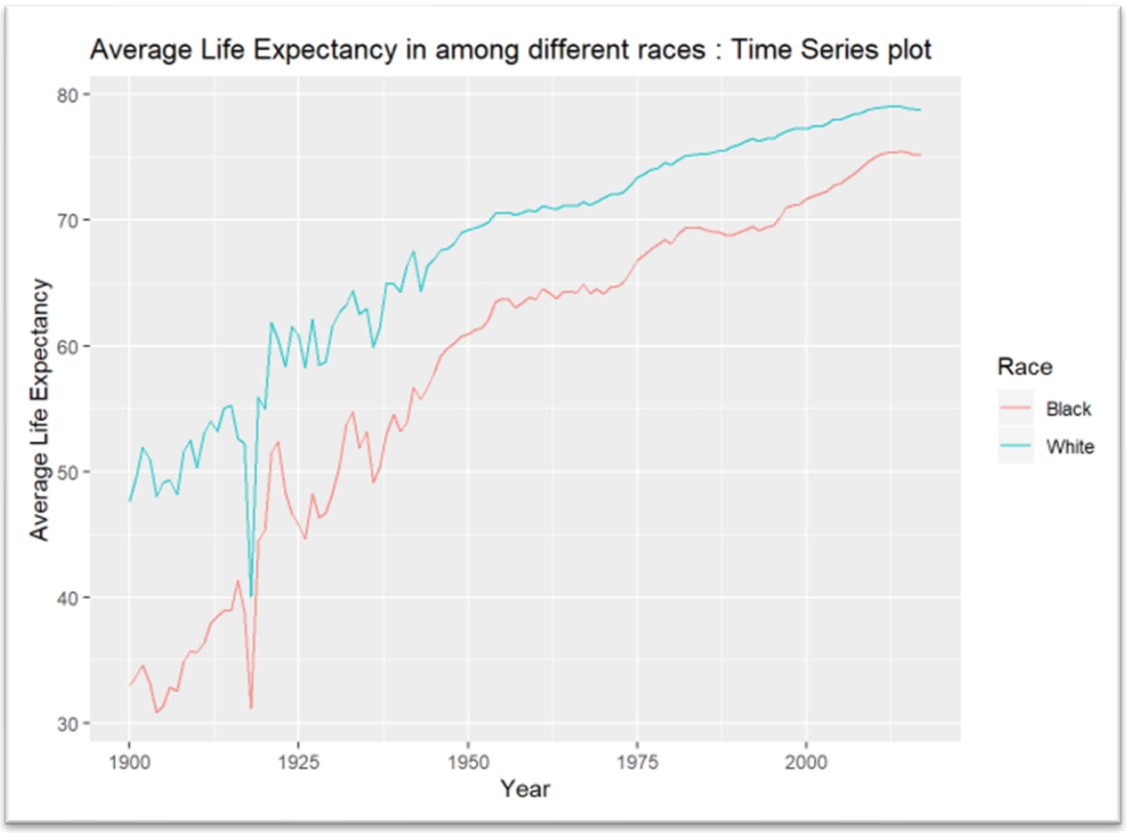
The data is oscillating substantially with drops in 1920 and 1939. There is an important increase in the gap of life expectancy in 1975 and according to the data a female outlives a male by almost 8 years. 40 percent of this sex differential in mortality is due to a twofold elevation of arteriosclerotic heart disease among men. Major causes of higher rates of arteriosclerotic heart disease in men include greater cigarette smoking among men; probably a greater prevalence of the competitive, aggressive Coronary Prone Behavior Pattern among men; and possibly a protective role of female hormones. In addition, men have higher death rates for lung cancer and emphysema, primarily because more men smoke cigarettes. Even in 2013, the data shows that the life expectancy gap is increasing yet again.

Now we look at life expectancy by race. We see the life expectancy of black and white Americans over the year (Fig. 6).

From the plot, we can observe that the overall average life expectancy of whites and blacks is increasing over the years. Also, we can see saturation in average life expectancy for whites from 2000. The difference between average life expectancy of whites and blacks have also reduced over years. Overall, the average life expectancy of whites is greater than male at all years with the highest margin at 1900. A number of sources seem to agree on the determinants of life expectancy that impact the racial gap:

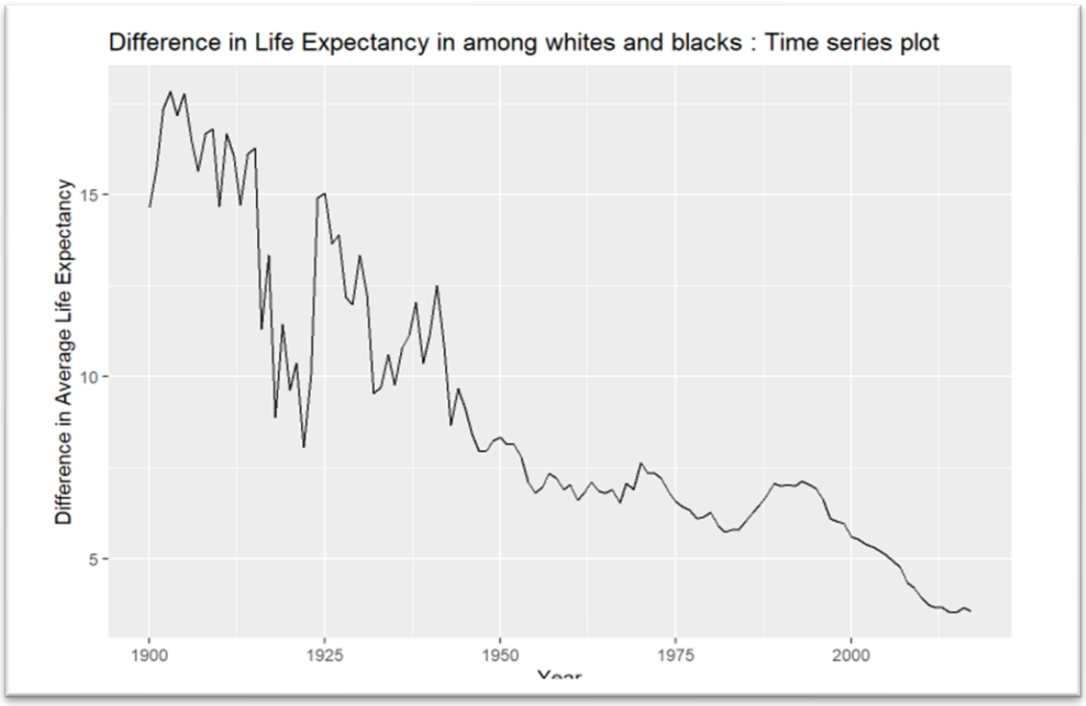
- Economic Circumstances
- Medical and Behavioural Issues
- Geographic and Environmental Conditions

**Figure 6**




We see (Fig. 7) that the difference in life expectancy was over 15 years in the early 19th century and has decreased to 7 years in the early twentieth century. The difference is continuously decreasing.

**Figure 7**




**Life expectancy and population density**

To explore the relation between life expectancy and population density look at changes in life expectancy in each state over three time periods: 1990 to 2000, 2000 to 2010, and 2010 to the present.

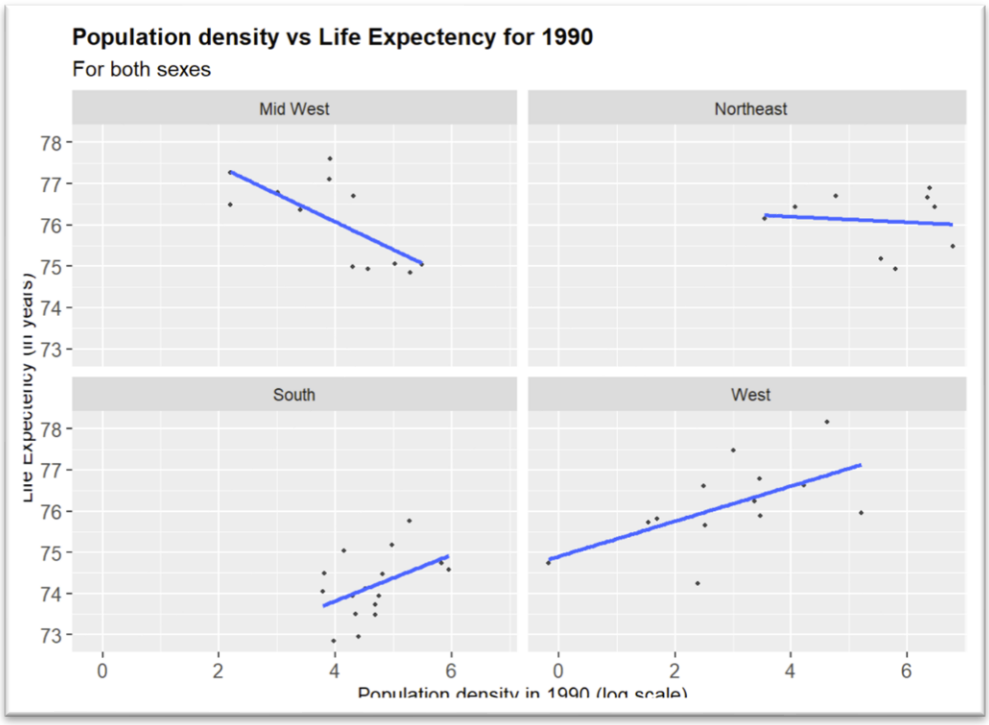
To see the trend we again fit a linear model and use a log scale for the population density. We have used log scale to respond to skewness towards large values of population density. Logarithmic scale results in values to fall into a range.

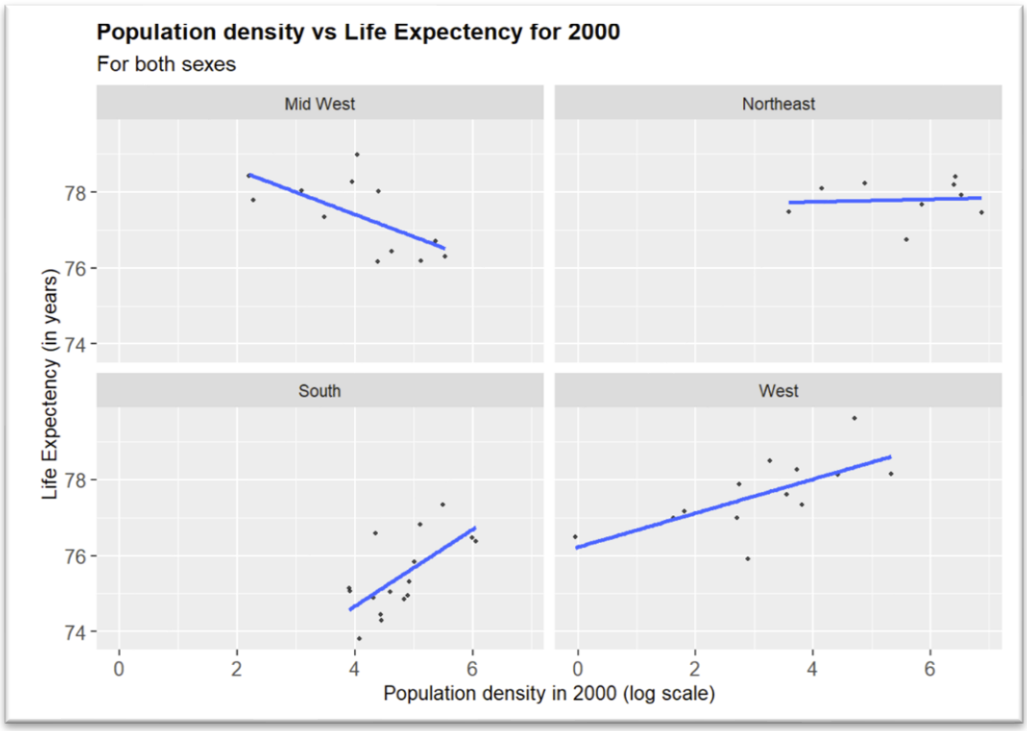
We begin by observing life expectancy for 1990. In Fig 4, we see that after 1990 there was a sudden dip in life expectancy which can also be seen in Fig. 8. The life expectancy in the Midwest is decreasing with the increase in population density. The Northeast region and south region has no apparent trend whereas the life expectancy in the west and the south region shows an increasing trend with the population density.

In 2000, we saw a similar trend to what we saw for 1990. The difference is in the south, where there is an increasing trend in life expectancy with the increase in population density in 2000. The Midwest again had a decreasing trend and northeast has no trend at all.

In 2010, every region is showing some kind of pattern similar to that in 2000, such as, in the MidWest region, we can observe a downward trend. Less populated states have more life expectancy while more populated states have less life expectancy. In the Northeast we see the same trend almost for all states in this region.

**Figure 8**


Population density vs Life Expectency for 1990
For both sexes
Mid West
Northeast
South
West
78
77
76
75
74
73
0
2
4
6
Population density in 1990 (log scale)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Life Expectency (in years)
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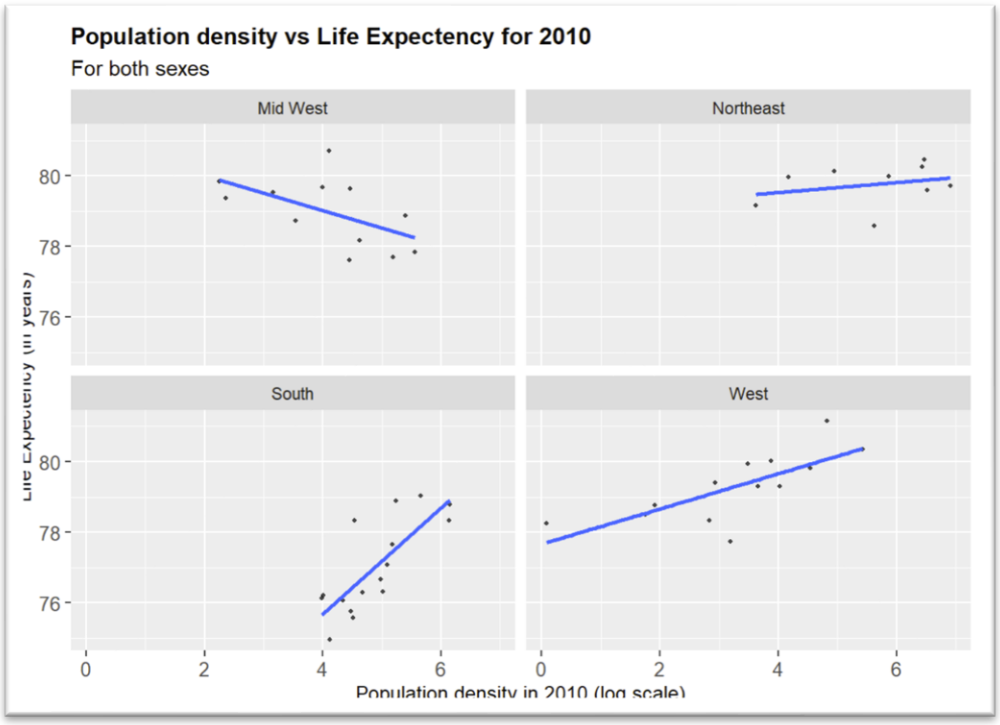
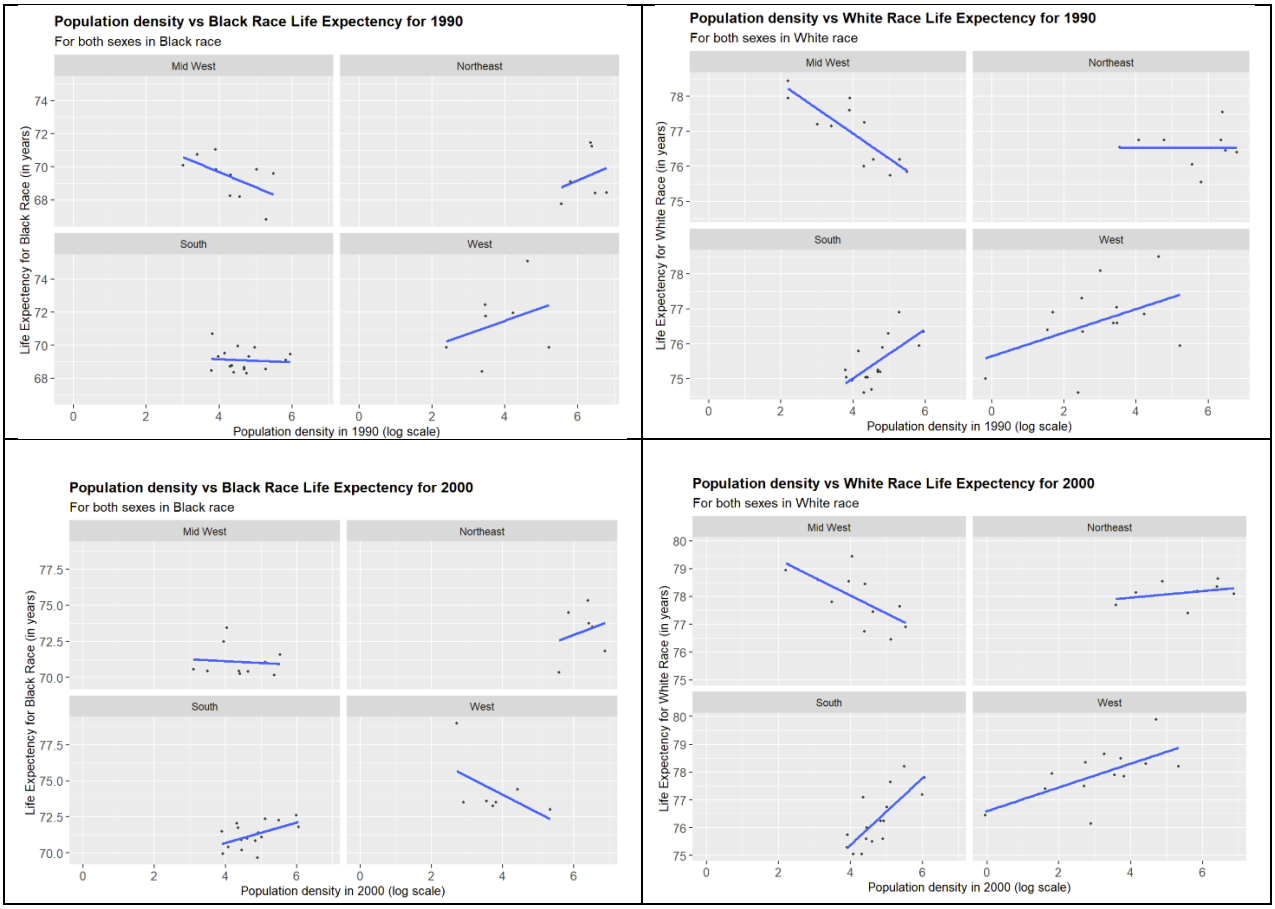



In the South region, we see a linear trend. Less populated states have less life expectancy while more populated states have more life expectancy. We can see a linear trend in the West region as well. Less populated states have less life expectancy while highly populated states have more life expectancy.

### Life expectancy for Blacks and Whites (race)



**Life expectancy vs Population density by race for year 1990**

Mid-West: In this region, the blacks and whites have similar trend. States with low population have high expectancy. It decreases with increase in population.

Northeast: In this region, the blacks have an increasing trend. States with lower population have low life expectancy and the states with high population have higher life expectancy. No trend is seen in the life expectancy of the whites in this region.

South: In this region, the blacks have same trend throughout while the whites have an increasing trend. The states with less population density have lesser life expectancy rate than the states with more population.

West: The trend for blacks and whites is the same in this region. Less populated states have less life expectancy, while the life expectancy increases as the population density increases.

**Life expectancy vs Population density by race for year 2000**

Mid-West: The whites in this region shows sharp decline in life expectancy as the population density increases. For the blacks, there's no trend as such.

Northeast: In this region, the blacks have an increasing trend like in the year 1990. While the whites show slight increase in the trend.

South: The blacks and the whites in this region shows an increasing trend. Less populated states have less life expectancy. Life expectancy increases with increase in population.

West: In this region, life expectancy for black decreases as population density increases. While for whites its the opposite.

**Executive summary**

Prevention and control of infectious diseases has had a profound impact on life expectancy during the 20th century. In the United States life expectancy at birth from the 19th century to 2014 increased from 46.3 to 76.1 years for men, and from 48.3 to 81.1 years for women. Improvements in nutrition, hygiene, and medical care

contributed to decreases in death rates throughout the lifespan. Life expectancy follows a similar increasing trend in all states and all regions of the United states. Women typically outlive men. The maximum gap in the life expectancy between females and males was recorded in 1975 at 8 years.

The gap has been decreasing until 2013(<6 years) but shows signs of increasing again in 2014. In 1900, the life expectancy difference between black and white men was 15 years. In 2014, it had dropped to a little over three years. Even as the life expectancy gap between black and white Americans narrowed, the life expectancy started to drop in the general population after a high in 2014.

A 2012 study showed that 80% of the racial life expectancy gap between black and white men could be attributed to socioeconomic factors. About 70% of the gap between black and white women can be attributed to socioeconomic factors. Income can be attributed to 52% of the difference for men and 59% for women. Life expectancy varies differently with population density for each region. In the mid-west the life expectancy decreases with increase in the population density. The Midwest is the only region which shows a negative correlation with life expectancy. The northeast region shows no trend at all and that tells us that the population density in northeast has no impact on life expectancy. The south and west regions show positive correlation i.e the life expectancy is increasing with the increase in population density. These observations are consistent from 1980,1990 and 2000 census data.

**Conclusion**

Life expectancy in the United states has been on a rise since the early 19th century but it shows signs of saturation in 2013-2014. Life expectancy cannot increase forever and is expected to plateau. Life expectancy follows a similar trend in all regions of the United States and individual states as well. Although there are a few states like Alabama and Oklahoma which have a flat line meaning the life expectancy has not changed much over the years.

Life expectancy in both males and females have been increasing with a sudden drop in life expectancy in 1920. Females have always outlived males. The difference in the life expectancy between males and females has been oscillating with a maximum gap of 8 years in 1975. Even though the gap has been reducing since then it saw a spike in 2013 and the data suggests that the gap will increase again.

Blacks and white Americans also have increasing life expectancy over the years with white outliving blacks. Although the difference in the life expectancies of blacks and whites have been increasing continuously from over 15 years of gap to less than 5 years.

**Future work**

We have explored how life expectancy has been varying in the United states since the 19th century. A lot of future work involves the reason for our observation. Finding out why women outlive males, causes of the difference in life expectancy between racial groups in the USA. We would also like to explore the most important factors which can help predict the life expectancy in the

United states. Shifts in life expectancy are often used to describe trends in mortality. Being able to predict how populations will age has enormous implications for the planning and provision of services and support.