

Project Part 1

Yushen Liu

Introduction

Understanding how healthcare spending relates to population well-being is a central question in global public health and economics. Countries invest billions of dollars each year in health systems, yet outcomes such as life expectancy vary widely. Exploring these relationships can reveal whether financial resources translate into tangible improvements in population longevity, and how demographic factors like sex or age influence these outcomes.

The following research questions guide this analysis:

- Do countries with higher healthcare spending per capita have higher average life expectancy?
- Do women tend to have a longer mean life expectancy than men across nations?
- Is life expectancy at birth positively related to life expectancy at age 60 across countries?

These questions are relevant beyond personal interest because they address global policy debates about health equity, efficiency of healthcare spending, and demographic differences in longevity. They examine measures of central tendency and association, focusing on mean life expectancy and its relationship with healthcare spending. The findings can contribute to a better understanding of how investments in healthcare relate to life outcomes, supporting evidence-based policymaking and international health planning.

GitHub REPO: https://github.com/Hud11e/STAT_3080-Project

Data summary

Primary Data Sources

This analysis uses two reputable global data sources [1, 2]:

(1): World Bank Group — Health Expenditure per Capita The World Bank provides internationally recognized economic and social development data collected from national statistical offices and verified through standardized reporting procedures. The dataset used reports current health expenditure per capita (in U.S. dollars) for each country. It includes data from the years 2020 and 2021, compiled from national accounts, government expenditure records, and international health agencies. The World Bank is considered a highly trustworthy primary source due to its rigorous data validation processes, global coverage, and consistency in reporting across countries.

(2): World Health Organization (WHO) — Life Expectancy at Birth The WHO dataset provides estimates of average life expectancy at birth for all member states. These values are derived from national vital registration systems, censuses, and household surveys, and are standardized to ensure international comparability. The WHO is a reliable and authoritative source for global health indicators, with transparent methodologies and peer-reviewed estimation procedures published regularly in the World Health Statistics reports.

Data collection

Both datasets represent population-level data. The World Bank dataset covers nearly all recognized countries, using official government-reported figures on national health expenditures. The WHO dataset includes life expectancy estimates for the full population of each country, using modeling adjustments where national data are incomplete. Therefore, the analysis reflects entire populations at the country level.

Data Modifications

- The World Bank health expenditure data was reshaped from a wide format (year columns) into a long format with three columns: Country Code, Year, and Health_Spending_per_Capita.
- The WHO life expectancy data was cleaned by extracting the numeric life expectancy value from a formatted string that also contained confidence intervals (e.g., “59.1 [58.3–59.9]” → “59.1”).
- Both datasets were filtered to include only the years 2020 and 2021, aligning the time period for direct comparison.
- Missing or non-matching countries were removed to ensure a clean, consistent dataset.

Appropriateness for the Research Question

The combined dataset is well-suited to the research question, containing 6 variables (As in Data dictionary section) measured at the national level for 2020–2021. This structure allows clear cross-country comparisons and supports descriptive analysis of whether greater healthcare investment is associated with longer average lifespan.

Data dictionary

Variable Name	Description	Units / Categories	Source
Country.Code	The three-letter ISO country code	Character (e.g., “USA”, “FRA”, “JPN”)	WHO / World Bank
Year	The calendar year for the observation	Numeric (2020, 2021)	WHO / World Bank
Sex	The sex category for life expectancy estimates	Categorical: “Male”, “Female”, “Both sexes”	WHO
Indicator	Describes which life expectancy measure is reported	Categorical: “Life expectancy at birth (years)”, “Life expectancy at age 60 (years)”	WHO
Life_Expectancy	The average number of years expected to live	Years (numeric)	WHO
Health_Spending_per_Capita	Total current health expenditure per person (in current U.S. dollars)	U.S. dollars (numeric)	World Bank

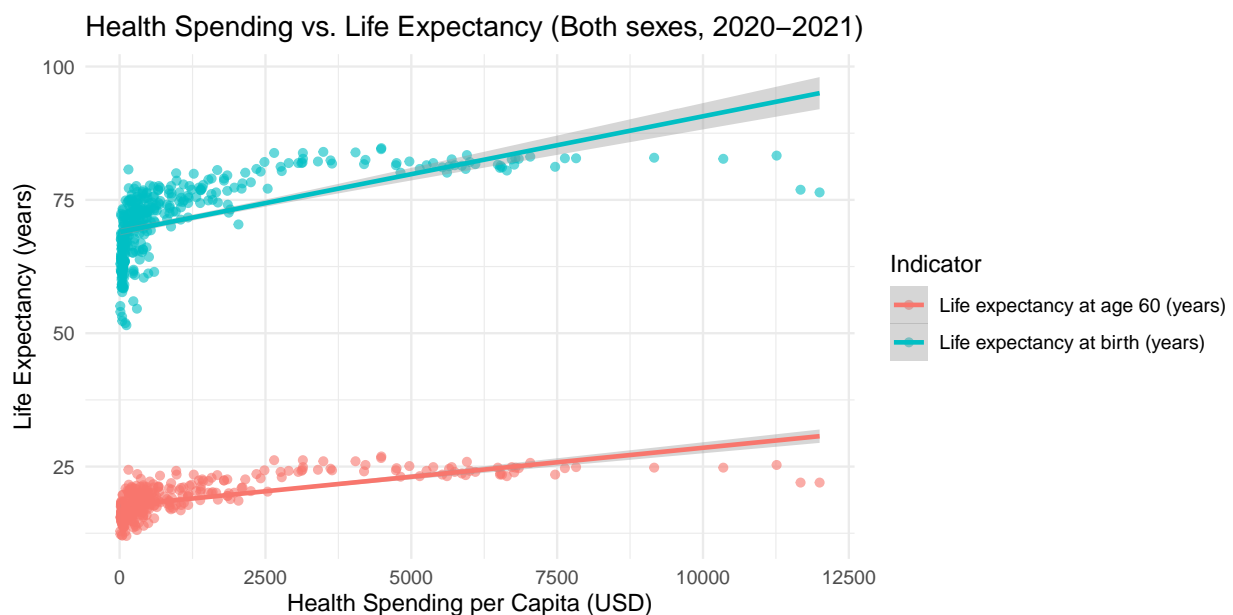
Exploratory Analysis

```
##   mean_spending median_spending mean_life median_life n_countries
## 1      1219.698       351.9434   71.67027        72.6        185
```

In the table above, across 185 countries, the average healthcare spending per capita was approximately **\$1,219.70 USD**, while the median spending was substantially lower at **\$351.94 USD**. This large gap between the mean and median indicates a strong right-skew in the distribution, where a small number of high-income nations spend vastly more per person than the majority of countries. The mean life expectancy was **71.7 years**, with a **median of 72.6 years**, showing that most countries have similar life expectancy levels clustered around the early 70s.

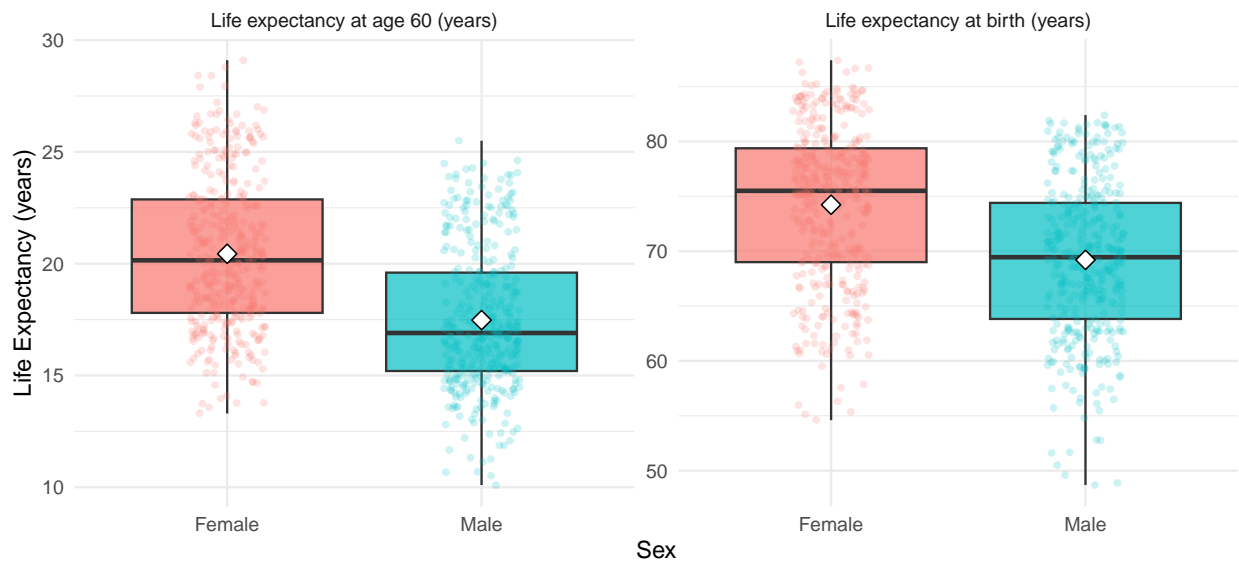
```
## # A tibble: 3 x 4
##   Sex      mean_life sd_life count
##   <chr>      <dbl>   <dbl> <int>
## 1 Both sexes    71.7     7.11   370
## 2 Female       74.2     7.23   370
## 3 Male        69.2     7.12   370
```

Life expectancy differs noticeably by sex across countries. On average, females live about 74.2 years, while males live about 69.2 years. The category for both sexes combined falls between these two averages at 71.7 years, as expected. The standard deviations of roughly seven years for all groups indicate moderate variability across nations, suggesting that sex-based differences in life expectancy are consistent globally. Overall, the results clearly show that women tend to live longer than men in nearly every country, a pattern that aligns with well-established global demographic trends. This finding will be further illustrated in the boxplot visualization below.

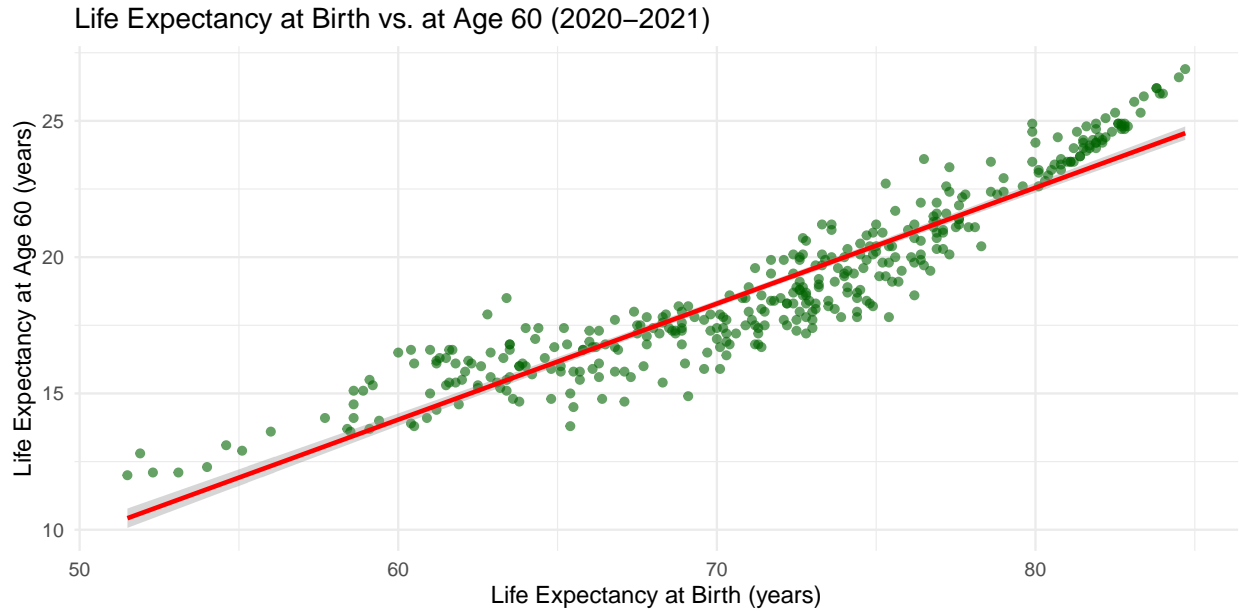


The scatterplot above shows a clear positive association between healthcare spending per capita and life expectancy for both indicators. Countries that invest more in healthcare generally exhibit higher life expectancy outcomes. The relationship is steeper for life expectancy at birth, indicating that increased health spending has a slightly stronger influence on early-life longevity compared to life expectancy at age 60. However, the pattern also displays diminishing returns—beyond roughly \$5,000 USD per capita, increases in spending correspond to only small gains in life expectancy.

Life Expectancy by Sex, split by Indicator (2020–2021)



The boxplots above show that females consistently have higher life expectancy than males across both indicators. On average, women live several years longer than men both at birth and at age 60, highlighting a robust and persistent gender gap in longevity. The difference appears slightly larger for life expectancy at birth, where the median gap between males and females is more pronounced.



The scatterplot above reveals a strong, nearly linear relationship between life expectancy at birth and life expectancy at age 60 across countries. Nations where people tend to live longer at birth also exhibit higher longevity later in life. The tight clustering of points around the regression line suggests a high positive correlation, implying that both indicators capture a consistent pattern of population health.

Conclusions

The exploratory analysis reveals a clear positive association between healthcare spending and life expectancy across countries. As shown in the scatterplot, nations spending around \$5,000 USD or more per person achieve life expectancies near 80 years, while countries with lower spending (below \$500 USD) typically fall between 55–70 years. The trend levels off beyond the \$5,000 mark, indicating additional spending yields smaller longevity gains among high-income nations.

Sex-based differences are also evident and consistent. Across all countries, females live about five years longer than males on average (74.2 vs. 69.2 years). The boxplots illustrate this persistent gap for both life expectancy at birth and at age 60, with the disparity slightly larger at birth.

Lastly, the scatterplot comparing life expectancy at birth and at age 60 shows a strong, nearly linear relationship. Countries with higher early-life survival (around 80 years at birth) also report longer old-age expectancy (about 23–25 years at age 60).

Overall, the descriptive results highlight substantial cross-country variation but coherent

global trends. Higher healthcare spending generally supports longer lives, women consistently outlive men, and early-life advantages carry into old age. These patterns provide an insight on the need and importance of focusing on national health expenditures.

Data Appendix

Table 2: Table A1. First 20 rows of the combined dataset

Country	Year	Sex	Indicator	Life Expectancy	Health Spending (USD)
LSO	2021	Male	Life expectancy at birth (years)	48.7	116.60
CAF	2021	Male	Life expectancy at birth (years)	49.6	46.25
LSO	2021	Both sexes	Life expectancy at birth (years)	51.5	116.60
SWZ	2021	Male	Life expectancy at birth (years)	51.6	296.83
SOM	2021	Male	Life expectancy at birth (years)	51.7	14.63
CAF	2021	Both sexes	Life expectancy at birth (years)	52.3	46.25
SOM	2021	Both sexes	Life expectancy at birth (years)	54.0	14.63
LSO	2021	Female	Life expectancy at birth (years)	54.6	116.60
SWZ	2021	Both sexes	Life expectancy at birth (years)	54.6	296.83
MOZ	2021	Male	Life expectancy at birth (years)	54.8	45.23
CAF	2021	Female	Life expectancy at birth (years)	55.4	46.25
GNB	2021	Male	Life expectancy at birth (years)	56.1	68.38
ZWE	2021	Male	Life expectancy at birth (years)	56.2	63.51
SOM	2021	Female	Life expectancy at birth (years)	56.3	14.63
SSD	2021	Male	Life expectancy at birth (years)	56.5	34.54
NAM	2021	Male	Life expectancy at birth (years)	57.3	413.51
AFG	2021	Male	Life expectancy at birth (years)	57.4	81.52
TCD	2021	Male	Life expectancy at birth (years)	57.5	37.59
MOZ	2021	Both sexes	Life expectancy at birth (years)	57.7	45.23
KIR	2021	Male	Life expectancy at birth (years)	57.8	262.54

References

[1] World Bank Group. (2024). *World Development Indicators: Health expenditure per capita (current US\$)*.

Retrieved from <https://data.worldbank.org/indicator/SH.XPD.CHEX.PC.CD>

[2] World Health Organization. (2024). *Global Health Observatory: Life expectancy data by country and sex*.

Retrieved from <https://www.who.int/data/gho>

AI Assistance Statement:

Parts of this report — including text refinement, structural organization, and code implementation — were supported by OpenAI’s GPT-5 model (ChatGPT, 2025). The analysis, data processing, and interpretation of results were conducted by the author.