Life Expectancy Analysis

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Introduction

I. General

Life expectancy is primarily regarded as the main indicator for views on the general health of certain populations. A major part of evaluating life expectancy is knowing which other variables could have an impact on the life expectancy, and how changes in one variable affects life expectancy. The primary goal of this project is to evaluate which demographic / social health-related factors are associated with variation in life expectancy across different countries and years. Specifically, there are many individual factors such as years in schooling, percentage of measles, and economy status. Previous research, including a study published in 2018 by Daniel et. al, have emphasized the role addressing social determinants can improve patient care. Daniel et. al claimed that there is a "15-year difference in life expectancy between the most advantaged and disadvantaged citizens". Based on this information and the dataset we chose, we wanted to explore along a similar line if there are specific factors that could affect life expectancy more than other factors.

Understanding what drives differences in life expectancy across countries is a central question in global health research. Life expectancy reflects the combined influence of economic development, healthcare access, disease burden, education, and demographic conditions, making it a powerful indicator of population well-being. In this project, we use an updated global health dataset covering 179 countries from 2000 to 2015 to investigate which factors most strongly predict life expectancy worldwide. The dataset includes harmonized measures of vaccination coverage, HIV incidence, BMI, alcohol consumption, mortality rates, schooling, population, GDP, and Gross National Income (GNI) classifications, with missing values carefully addressed through regional and temporal imputation methods. Countries with excessive missingness were removed to ensure high data quality, and economic categories were aligned with World Bank standards for comparability.

Using this dataset, our goal is to address the research question: Which health, economic, and demographic factors are significantly associated with life expectancy across countries? To answer this, we employ a reproducible statistical analysis along with appropriate regression modeling. Rather than conducting individual analyses of every variable, we focus on a targeted

set of meaningful predictors, such as income level, vaccination rates, HIV burden, nutritional indicators, and schooling, to evaluate their associations with life expectancy in a clear and interpretable way.

This project demonstrates proficiency in data cleaning, statistical modeling, and effective communication of results. By integrating global health indicators into a coherent analytical framework, we aim to provide insights that are accessible to allied researchers while highlighting key factors that contribute to disparities in life expectancy around the world.

II. Dataset

The dataset used in this project came originally from Kaggle, which was sourced from the WHO (World Health Organization). The actual data was compiled from across three sources: WHO, World Bank data, and Our World in Data - a University of Oxford project. Each row represents a country and all the data collected from one year in that country across all the other variables. Even though the dataset comes from multiple sources, they are all adjusted and standardized. The observational unit was a country-year. All the dataset variables are listed below:

Response Variable: Life_expectancy: The average life expectancy for both genders across different years, from 2000 to 2015.

Predictor Variables: Economic and Demographic – GDP_per_capita: Gross Domestic Product per capita in current US Dollars. Population_mln: Total population of a country in millions. Schooling: Average years individuals aged 25 and over have spent in formal education. Economy_status_Developed: A binary indicator (0 or 1) denoting whether a country is classified as 'Developed'. Economy_status_Developing: A binary indicator (0 or 1) denoting whether a country is classified as 'Developing'.

Lifestyle – Alcohol_consumption: Records alcohol consumption in litres of pure alcohol per capita for individuals aged 15 years and over. BMI: Body Mass Index, a measure of nutritional status in adults (defined as a person's weight in kilograms divided by the square of that person's height in meters). Thinness_ten_nineteen_years: Prevalence of thinness among adolescents aged 10-19 years (specifically, BMI $<$ -2 standard deviations below the median). Thinness_five_nine_years: Prevalence of thinness among children aged 5-9 years (specifically, BMI $<$ -2 standard deviations below the median).

Mortality and Disease – Infant_deaths: Represents the number of infant deaths per 1,000 population. Under_five_deaths: Represents the number of deaths of children under five years old per 1,000 population. Adult_mortality: Represents the number of deaths of adults per 1,000 population. Hepatitis_B: Represents the percentage of coverage for Hepatitis B (HepB3) immunisation among 1-year-olds. Measles: Represents the percentage of coverage for Measles containing vaccine first dose (MCV1) immunisation among 1-year-olds. Polio: Represents the percentage of coverage for Polio (Pol3) immunisation among 1-year-olds. Diphtheria: Represents the percentage of coverage for Diphtheria tetanus toxoid and pertussis (DTP3)

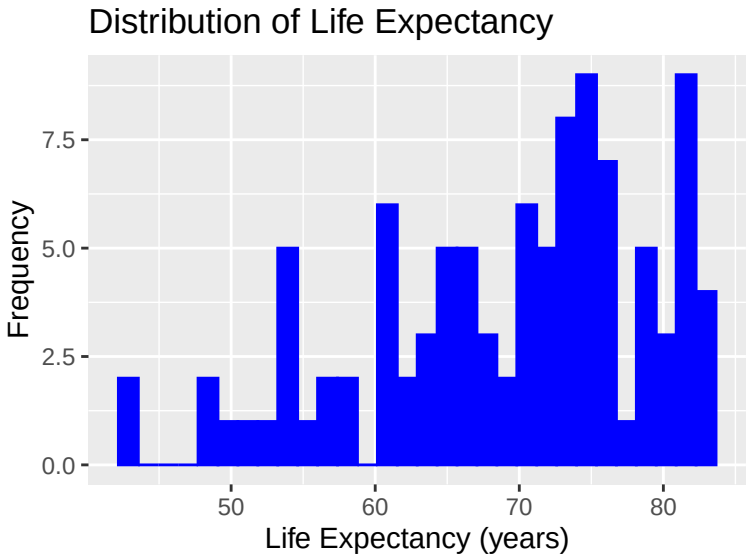
immunisation among 1-year-olds. Incidents_HIV: Represents the incidents of HIV per 1,000 population aged 15-49.

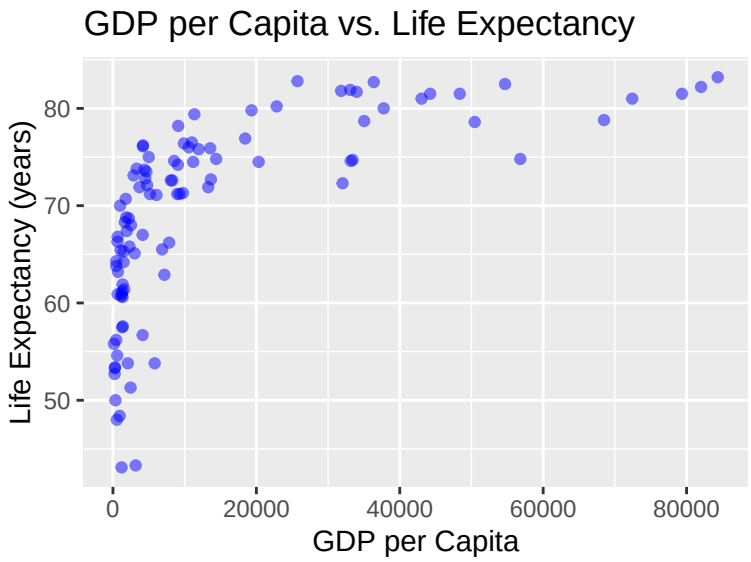
Observational Units: Country: A list of 179 distinct countries included in the dataset. Region: Categorises the 179 countries into 9 geographical regions, such as Africa, Asia, Oceania, and the European Union. Year: The observed year, ranging from 2000 to 2015.

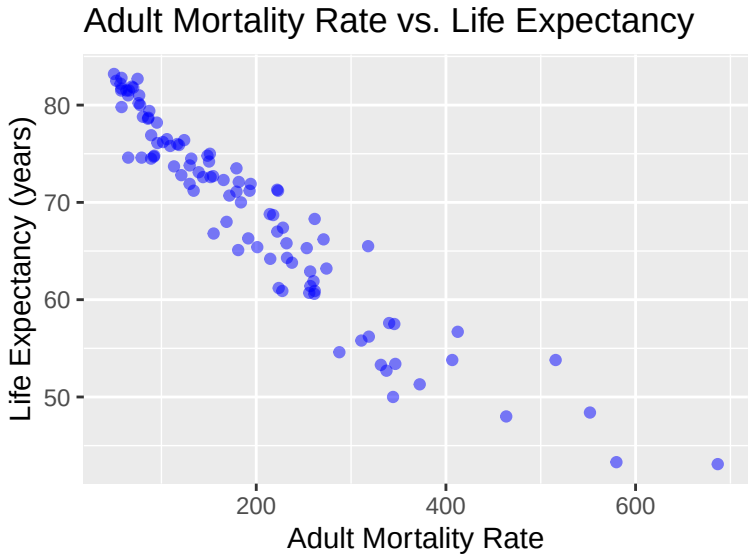
III. Rationale

The reason for this data analysis is that if helps identify which health and economic variables most strongly explain differences in life expectancy. It also helps shows how different diseases / vaccinations and child and adult mortality can contribute to the overall health of a nation. This data analysis can also help us make conclusions on what types of health policy can be recommended or suggested in order to target preventable health risks in certain countries.

IV. Exploratory Data Analysis







The EDA helps us visualize some of the aspects of this dataset. It helps look at life expectancy as a whole across all the countries, and to help see if it is normally distributed. Additionally, the two scatter plots visually confirm whether economic indicators (GDP per capita) and health indicators (adult mortality) are strong predictors of life expectancy.

Methodology

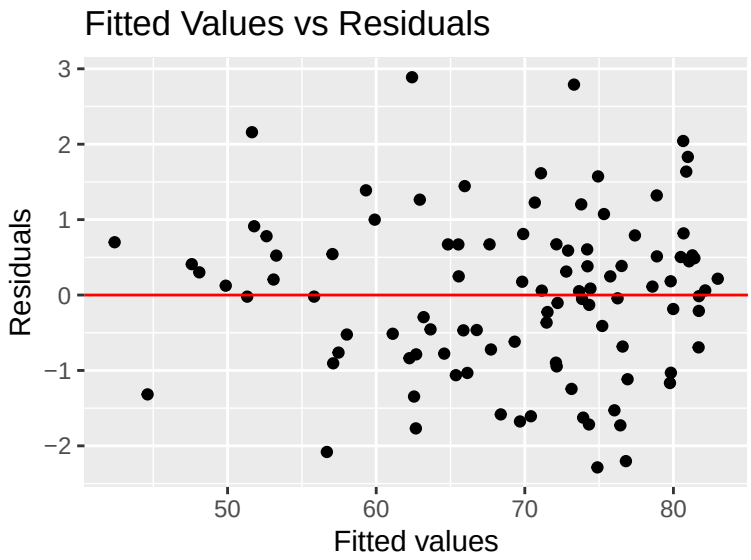
The goal of this analysis was to identify how the different variables in the dataset impacted life expectancy across different countries and years. We selected a linear regression model over

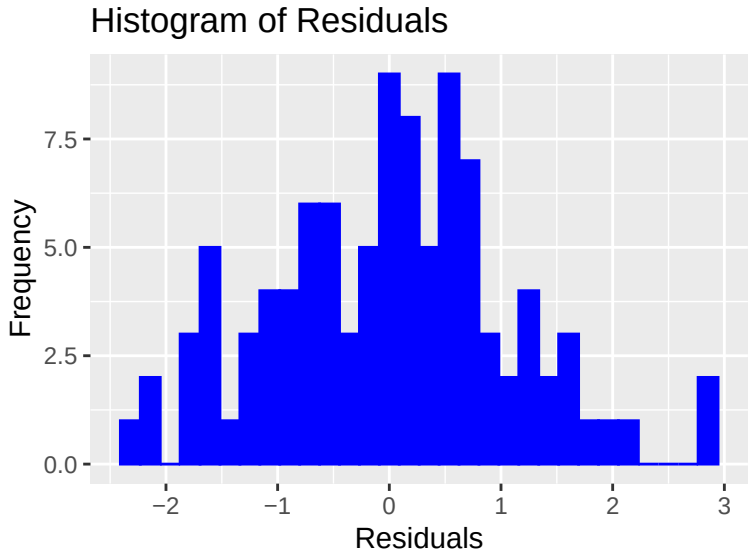
other models because the outcome variable (life expectancy) is continuous and the research question focuses on estimating relationships between predictors and mean life expectancy, while holding other variables constant. A multiple linear regression is appropriate for this dataset because the outcome is continuous, the predictors are a mix of numerical and categorical variables, and the goal is to estimate how each variable relates to life expectancy. Other methods such as logistic regression, ANOVA, and t-tests, were not appropriate here because they are designed for categorical outcomes or for comparing a small number of group means. Our dataset includes a continuous response and many quantitative predictors, so linear regression is the best and most efficient method that fits our research question.

For replication, the linear regression uses the equation shown below as a guide, with life expectancy as the output, and the other variables as its predictors. When replicated, it should be ensured the data is loaded into R, and that when inputting this model into R with the lm() function, that life expectancy is the output, and that all other variables are quantitative except Economy Status Developed and Region, which are factors and therefore dummy variables in this linear regression. Results are shown using the summary() function. P-values and slopes were assessed for the goals of this project.

Yi= 0 + 1 (Yeari)+ 2 (InfantDeathsi)+ 3 (Under5Deathsi)+ 4 (AdultMortalityi)+ 5 (AlcoholConsumptioni)+ 6 (HepatitisBi)+ 7 (Measlesi)+ 8 (BMIi)+ 9 (Polioi)+ 10 (Diphtheriai)+ 11 (HIVIncidencei)+ 12 (GDPperCapitai)+ 13 (PopulationMillionsi)+ 14 (Thinness10to19i)+ 15 (Thinness5to9i)+ 16 (Schoolingi)+ 17 (EconomyStatusDevelopedi)+r=1 K−1 r (Regionri)+ i

The residual plot is symmetrically distributed around the horizontal axis, showing that our data satisfied the assumption of linearity. The residuals appear to be roughly vertically evenly spaced along the y axis, satisfying the assumption of constant variance of the errors. The histogram of the residuals also appears to be roughly symmetrical, satisfying the assumption of a normal distribution of errors. Finally, for independence in this dataset, each row represents a specific country in a specific year. Since each country operates independently with its own health system, economy, and demographic conditions, it makes sense to assume that the error for one observation doesn't directly affect the error for another. Because the same country can appear multiple times (for different years), it's possible that a country's values might be somewhat related over time. However, the model treats each country-year as its own observation, and we also included variables like Region and Economy Status, which already help capture similarities between countries that might otherwise create dependence. Because of this, even though small within-country patterns over time could exist, assuming that the errors are independent overall is still a reasonable and practical assumption for this analysis. Plots for the assumptions are shown below:





Results

Linear regression of life expectancy and its predictors:

```
# A tibble: 25 x 3
   Variable                                Estimate P_value
   <chr>                                      <dbl>   <dbl>
 1 (Intercept)                               -162.    0.032
```

2	Year	0.126	0.001
3	Infant_deaths	-0.127	0.03
4	Under_five_deaths	-0.014	0.702
5	Adult_mortality	-0.044	0
6	Alcohol_consumption	-0.041	0.588
7	Hepatitis_B	-0.022	0.162
8	Measles	0.01	0.315
9	BMI	-0.3	0.035
10	Polio	0.056	0.407
11	Diphtheria	-0.079	0.225
12	Incidents_HIV	-0.018	0.859
13	GDP_per_capita	0	0.346
14	Population_mln	0.001	0.597
15	Thinness_ten_nineteen_years	-0.304	0.001
16	Thinness_five_nine_years	0.21	0.009
17	Schooling	0.066	0.545
18	Economy_status_Developed1	2.59	0.003
19	RegionAsia	1.42	0.028
20	RegionCentral America and Caribbean	3.33	0
21	RegionEuropean Union	0.48	0.638
22	RegionMiddle East	1.48	0.079
23	RegionOceania	0.246	0.825
24	RegionRest of Europe	1.06	0.19
25	RegionSouth America	3.10	0.001

Results were analyzed with emphasis on the p-values resulting from the T tests that were run on each individual variable, while holding others constant. The null hypothesis for each variable was that the slope, or beta, was equal to 0. The alternative hypothesis is that the slope/beta is not equal to 0. Each T test had a t distribution under the null hypothesis with 1 degree of freedom. These p values were analyzed with a significance value of alpha equals .05. The variables where the null hypothesis was rejected and we had enough evidence, based on the data sourced from Kaggle, to say that there is a relationship between said variable and life expectancy are as follows: Year, Infant_deaths, Adult_mortality, BMI, Thinness_ten_nineteen_years, Thinness_five_nine_years, Economy_status_Developed1, RegionAsia, RegionCentral America and Caribbean, and RegionSouth America.

Discussion

References

Daniel, H., Bornstein, S. S., & Kane, G. C. (2018). Addressing social determinants to improve patient care and promote health equity: An American College of Physicians Position

Paper. Annals of Internal Medicine, 168(8), 577–578. https://doi.org/10.7326/m17-2441 Life Expectancy & Socio-Economic Determinants Dataset CSV download free | Open Data Marketplace. (2025, July 24). https://www.opendatabay.com/data/ai-ml/0bdbea7e-f40b-4c41-b010-37537d03a723?utm_source