Project Part 2

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Introduction and Brief Data Description

In part 1, we considered three questions about how GDP per capita and health expenditure relate to national health outcomes. They are as follows:

1. Do countries with health expenditure above the median have lower infant mortality rates than those below the median?

2. Do countries with health expenditure above the median have higher life expectancy than those below the median?

3. Among countries with below-median GDP per capita, do those spending more than 5% on health expenditure have higher life expectancy than those spending less than 5%?

In order to investigate the answers to these questions, we used World Bank data to build a custom 2022 dataset with GDP per capita, health expenditure, infant mortality rate, and life expectancy for each country. Health expenditure is the share of GDP spent on healthcare (public and private combined).

Exploring Question 2: Life Expectancy vs Health Expenditure Level

We test whether mean life expectancy is higher for countries above the median health expenditure (% of GDP) compared with those below.

Note: After looking at the data, we noticed an oddly low reported life expectancy for the Central African Republic of 18.82, which appears to be a misreported statistic. For that reason, we are going to avoid including the CAR in our analysis of this question.

Table 1: Life expectancy by health expenditure level (2022)

Health Expenditure Group	n	Mean Life Expectancy	Variance	SD
Below Median	94	70.76	44.19	6.65
Above Median	94	74.61	46.37	6.81

Analysis of the table, histograms, and QQ plots

1. Looking at this table, we see that the size of each of the two groups is nearly identical, which is reasonable since we split the countries by comparing their health expenditure to the *median* health expenditure. We also see that the means differ noticeably; the group below the median has a life expectancy over 3 years lower.
2. We see that the variance of each group is relatively the same (44.19 vs 46.37). However, we cannot claim that the population variances are the same with strong evidence, so we cannot truly state homogeneity of variance here.
3. Looking at the histograms and QQ-plots, there seem to be questions regarding normality. However, each group has $n > 30$.

Test to Conduct

We are conducting a one-tailed two-sample t-test to determine if the mean life expectancy for the above median group is greater than that for the below median group.

ASSUMPTIONS:

1. Independence: Assuming independence between groups and within groups. However, there could be some spatial dependence that we will set aside for now.
2. Normality: Each group has $n > 30$, so even though the EDA highlighted concerns regarding normality, we will proceed.
3. Homogeneity of Variance: We showed through our EDA that there is not necessarily homogeneity of variance, and so as a result, we will default to Welch's t-test, which does not require this assumption (unlike the Student's/pooled t-test).

4. Continuous Outcome Variable: Life expectancy is a continuous numerical variable.
5. Single tail is justified: Through our background and common knowledge of the subject, we had justification before looking at the data to posit an alternative hypothesis that the mean life expectancy is greater for the above median countries than it is for the below median countries.

Conducting the One-Tailed Two-Sample T-test

For this Welch's t-test, our null hypothesis is that the means are the same (i.e., there is no statistically significant difference between the two means). To reiterate, our alternative hypothesis is that the above median group has a greater mean life expectancy than the below median group. We are testing at an alpha (significance level) = 0.05.

```
##
##  Welch Two Sample t-test
##
## data:  Life_Expectancy_2022 by Health_Exp_Group
## t = -3.9239, df = 185.89, p-value = 6.128e-05
## alternative hypothesis: true difference in means between group Below Median and group
## 95 percent confidence interval:
##      -Inf -2.22885
## sample estimates:
## mean in group Below Median mean in group Above Median
##                   70.76155                   74.61295
```

From the results of the t-test, we see that the t-statistic came out to -3.9239. With a df = 185.89, the p-value is calculated to be 6.128e-05 < 0.05. As a result, at alpha = 0.05, we can state that the difference in means is statistically significant and that the mean life expectancy for above median countries is greater compared to below median countries.

Conclusions and Limitations

Our analysis provided statistically strong evidence that countries that spend above the median percentage of GDP on healthcare have a significantly higher life expectancy. Practically, this suggests that focusing more national resources on healthcare is associated with a longer life expectancy. A possible limitation is that is merely an observational analysis, meaning

that we cannot say that more spending causes longer lives. There may be many other confounding variables. Wealthier countries that spend more on healthcare could have better infrastructure, nutrition, education, etc., which could also improve life expectancy. Moreover, there could be issues with complete independence as neighboring countries share similar policies and conditions. Additionally, although our histograms and QQ-plots showed some deviations from normality, each group has over 30 counts, helping the normality. In order to improve in the future, we could control for GDP per capita and development level. We could also explore with multiple years, preferably more recent to improve our accuracy.

```
library(pwr)

# Calculate effect size
pooled_sd <- sqrt((44.19 + 46.37) / 2)
effect_size <- (74.61 - 70.76) / pooled_sd

# Calculate power
pwr.t.test(n = 94,
           d = effect_size,
           sig.level = 0.05,
           type = "two.sample",
           alternative = "greater")
```

```
##
##      Two-sample t test power calculation
##
##               n = 94
##               d = 0.5721469
##       sig.level = 0.05
##           power = 0.9881903
##     alternative = greater
##
## NOTE: n is number in *each* group
```

For this statistical power test, the calculated power was at 0.988, meaning that our sample size of 94 countries per group gave us a 98.8% chance of detecting a real difference if one existed. The high power improves our confidence that our significant result shows a real pattern, rather than chance.

- discuss implications of findings
- what limitations existed (see issues in assumptions)
- run test for statistical power ## References ChatGPT (through Cursor and directly through OpenAI) was used for drafting portions of the R code, debugging assistance, cleaning up some of the wording, and answering Statistics-related questions.