1. Introduction

1.1 Research Question

"What is the relationship between gender inequality and breast cancer case-fatality rates across different countries in 2022?"

Investigating the correlation between the Gender Inequality Index (GII) and breast cancer case-fatality rates is critical because systemic gender disparities directly impact women's access to healthcare, early diagnosis, and treatment quality. Higher GII values reflect inequalities in reproductive health, economic participation, and political empowerment, which can delay cancer detection and reduce survival rates (Nations United).

This relationship has been studied before using 2018 World Health data, investigating several female-specific cancers such as cervical cancer, ovarian cancer, and breast cancer. For example, *Kavousi et al. (2024)* specifically focused on breast cancer, and found a weak association between Gender Inequality Index and Breast cancer incidence but identified a non-linear relationship between GII and Breast cancer mortality, with higher mortality rates in regions with greater gender inequality. This investigation aims to build on this previous study by examining 2022 data, as this is the most recent and fully updated dataset available from WHO databases.

Focusing on case-fatality rates rather than mortality rates provides a more precise measure of how gender disparities impact survival outcomes after diagnosis. Mortality rate refers to the overall number of deaths in a population, which can be influenced by factors such as incidence rates and population demographics (Merriam-Webster). In contrast, care-fatality rate specifically measures the proportion of diagnosed individuals who die from the disease, making it a better indicator of healthcare access, treatment effectiveness, and systemic inequalities. This is important because it helps determine whether gender inequalities are impacting the quality of care and treatment that female patients receive, leading to higher or lower fatalities. Hence, understanding this connection is crucial in ensuring that all women, regardless of where they live, have an equal chance of fighting and surviving this disease.

1.2 Background Information

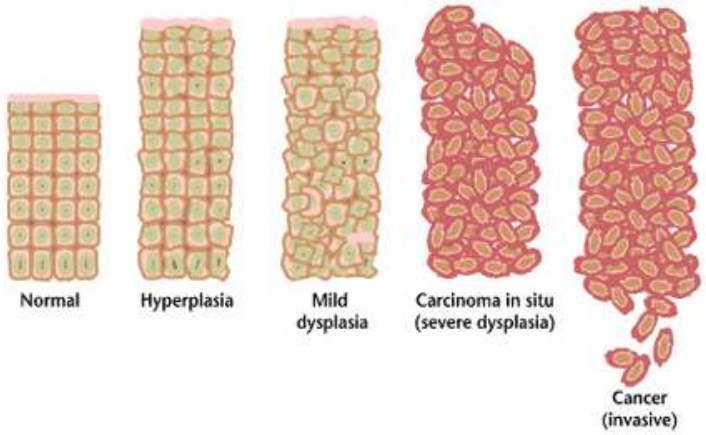
1. Cancer

Cancer refers to a group of diseases involving abnormal cell growth with the potential to invade or spread to other parts of the body. Normally, cells grow, divide and die in an orderly way, but in cancer, this process is disrupted, leading to tumor formation. Cancer cells grow uncontrollably, evade apoptosis (cell death), spread to other areas, trick the immune system, and rely on alternative energy sources. These abnormalities often result from genetic mutations caused by cell division errors, environmental factors such as smoking and UV radiation, or inherited mutations (Overview of Cancer).

When cancer metastasizes, it retains characteristics of its original form, for instance, breast cancer that spreads to the lungs is still BREAST cancer. Some metastatic cancers can be managed but are often life-threatening. However, not all tissue changes are cancerous. Conditions like hyperplasia, dysplasia, and carcinoma in situ involve abnormal cell growth but may not progress to cancer, particularly with early

treatment. This is illustrated in Figure 1, and can be detected and managed with regular checkups (Canadian Cancer Society).

***Figure 1*:** Depicts the development of Cancer.



2. Breast Cancer

In 2022, WHO, reported approximately 2.3 million breast cancer diagnoses among women worldwide. Breast cancer, a carcinoma, originates from epithelial cells in the breast ducts or lobules. *Anderson et al.* (2010) state that breast cancer is among the most prevalent cancers, primarily affecting women, who account for over 99% cases and leaving only 1% of male cases. This significant gender disparity makes breast cancer a valuable case for examining inequalities in healthcare, as it predominantly impacts females.

The most common types include invasive ductal carcinoma (IDC) and lobular carcinoma. Symptoms often involve lumps and breast shape changes. Mutations in tumor suppressor genes like BRCA1 and BRCA2 elevate the risk of breast cancer (Casaubon et al, 2013). Healthcare providers diagnose breast cancer using mammograms, ultrasounds, and biopsies to detect precancerous changes like DCIS and LCIS shown in Figures 2 and 3 (Overview of Cancer).

Figure 2: Shows DCIS

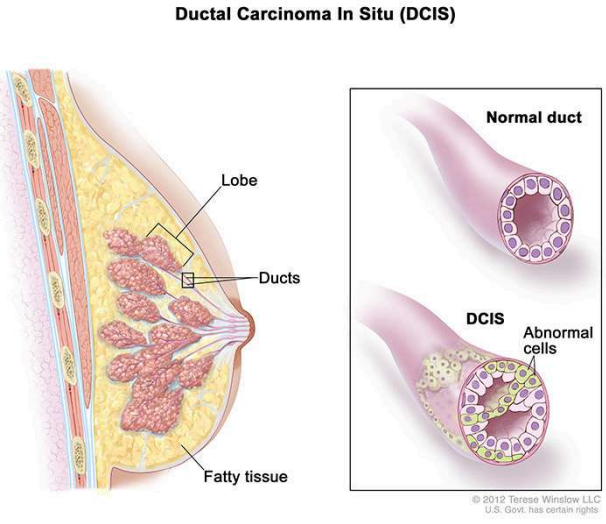
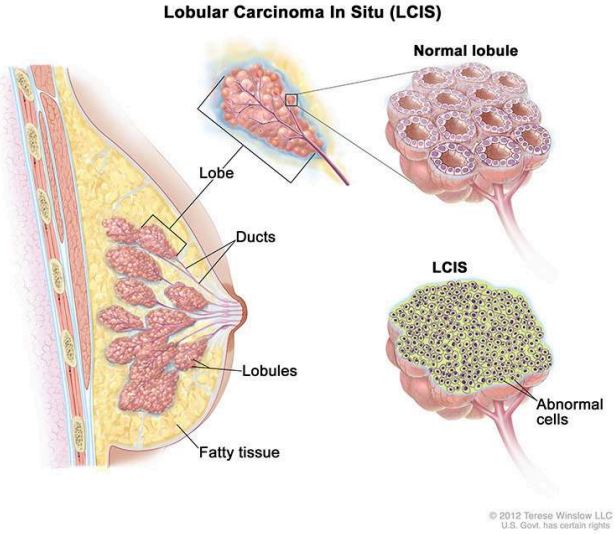
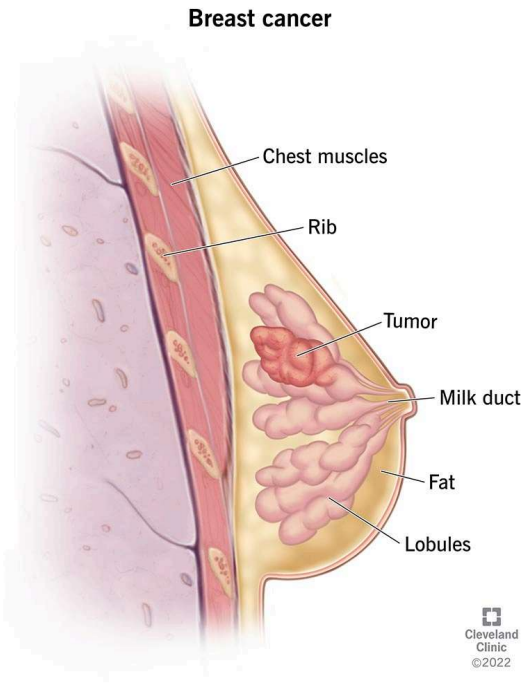


Figure 3: Shows LCIS



However, late diagnosis often occurs due to limited access to these diagnostic facilities and then treatment options resulting in fully developed breast cancer as seen in *Figure 4.* In countries with significant gender inequality, there may be barriers to accessing these essential services, hence the objective of the investigation is to explore whether or not these barriers exist and have a significant impact on breast cancer case-fatality rates.

Figure 4: Depicts fully developed breast cancer



3. Gender Inequality Index (GII)

GII is a composite measure developed by the United Nations Development Programme (UNDP) to assess gender-based disparities in countries across three key dimensions; Reproductive health, Empowerment, and Labour Market Participation. Reproductive health dimensions used maternal mortality rates and adolescent birth rates as an indicator to reflect poor access to healthcare, with a particular focus on female health, as reproduction is a crucial female role. The empowerment dimension assesses the political and educational opportunities available to women, including the percentage of parliamentary seats held by women and the level of educational attainment. Empowered women are more likely to influence policies that improve public health systems, including those that focus on early cancer detection, and healthcare infrastructure. Finally, the labour market participation dimension evaluates economic participation, specifically the female labour force participation rate. Women's economic power often determines their ability to afford and access healthcare services, including cancer treatment facilities. All these indicators are combined to calculate a country's GII score, which reflects the level of inequality in that region; the higher the GII score the more unequal the social structure in the country (Understanding the Gender Inequality Index (GII) and Its Impact).

4. Human Development Index (HDI)

HDI, developed by the UNDP, assesses countries' overall development based on health, education, and standard of living. It incorporates life expectancy, mean and expected years of schooling, and Gross National Income per capita, with scores ranging from 0 to 1, where higher values indicate greater development. This index is relevant to this investigation as it provides context regarding the development of countries and their resources, which can impact healthcare systems, including access to breast cancer diagnosis and treatment. The HDI categorizes countries into different groups: Very High, High, Medium, and Low Human Development. This study considers countries from each group to examine how development levels may also correlate to the GII, and then further control for HDI when finding the correlation between GII and case-fatality rates due to breast cancer .

5. Relationship between GII and HDI

Countries with lower HDI values often have higher GII values, indicating greater gender inequality. This investigation will analyze recent data to confirm this correlation, assessing whether gender inequality remains a significant barrier to development and healthcare access. By establishing the relationship, the study ensures that observed trends in breast cancer case-fatality rates are attributed to gender based disparities rather than general developmental differences.

2. Exploration

2.1 Hypothesis

Hypothesis: Countries with higher Gender Inequality Index (GII) values will exhibit higher Breast Cancer Case-Fatality rates.

This hypothesis is grounded in the understanding that elevated GII values reflect systemic disparities in reproductive health, empowerment and labour market participation which can hinder women's access to timely and effective healthcare services, including cancer detection and treatment.

2.2 Methodology

Firstly, the relationship between HDI and GII will be explored to ensure that they are inversely related as suggested by the Human Development Report. To explore the primary focus of this investigation, an observational cross-sectional study design will be used. Data from various countries will be collected from the year 2022, focusing on GII values, Breast Cancer Incidence,and Mortality rates, which will be used to calculate Case-fatality rates. By statistically analyzing this data, I aim to identify correlations and assess the impact of gender inequality on breast cancer outcomes.

Table 1: Variables outlined and explained

Type of Variable	Variable	Control Method	Reason
Independent Variable	Gender Inequality Index Values	GII values are used as reported by the HDR	GII quantifies gender disparities and inequality

		from the UNDP	that may influence healthcare access and breast cancer outcomes.
Dependent Variable	Breast Cancer Case-Fatality Rates	CFR is calculated using incidence and mortality rates obtained from standardized health databases (WHO).	CFR measures the proportion of diagnosed breast cancer to those that result in death reflecting healthcare quality especially focusing on women.
Confounding Variable	HDI values	Countries are categorized into very high, high, medium, and low HDI levels, with 5 countries randomly selected from each group.	HDI accounts for overall economic development, healthcare infrastructure, and education, which influence both GII and CFR. Controlling for HDI isolates the effect of gender inequality.
	Age	CFR data will be age-standardized using reports that control for age distribution.	Age is a major risk factor for breast cancer. Standardizing rates prevents misleading comparisons due to demographic differences.
	Gender	Only female breast cancer cases are analyzed.	Since GII specifically measures gender inequality affecting women, including male breast cancer cases would introduce confounding variables.
	Year	Data from a single year (2022) is used for all countries.	Ensures that variations in CFR are not due to time-dependent medical advancements or changes in healthcare policies.
	Data-Base	incidence and mortality rates are taken from the same global health database (e.g., WHO, GLOBOCAN)	Using a consistent data source ensures uniformity in definitions, data collection methods, and reporting standards.
	Countries Selected	Countries are selected through stratified	This prevents selection bias while ensuring that

		sampling within each HDI category using a random generator.	countries across different development levels are included.

2.3 Stratified Sampling of Countries:

Stratified sampling will be used, with a random generator selecting 5 countries from each HDI group, as defined by the Human Development Report:

Low HDI = <0.550
Medium HDI = 0.550-0.699
High HDI = 0.700-0.799
Very High HDI = >0.800

See *Table 2* for randomly generated countries. After randomly generating a country, the Human Development Report databases and WHO databases for breast cancer incidence and mortality rates were cross-referenced to ensure the generated countries had the required data necessary to continue through the investigation. This random generation process controlled for potential researcher bias that could skew the data (Wheel of names).

Table 2: Generated countries with respective HDI group and Value

HDI Group	Country	HDI Value
Very High	Slovenia	0.926
	Japan	0.92
	United Kingdom	0.94
	Austria	0.926
	Lithuania	0.879
High	Armenia	0.786
	Dominican Republic	0.766
	Ecuador	0.765
	Uzbekistan	0.727
	China	0.788
Medium	Cambodia	0.6
	Guatemala	0.629

	India	0.644
	Zambia	0.569
	Iraq	0.673
Low	Somalia	0.38
	Yemen	0.424
	Nigeria	0.548
	Pakistan	0.54
	Guinea	0.471

2. 4 Data Sources:

1. Gender Inequality Index (GII) Values: Obtained from UNDP's Human Development Reports, which provide annually updated and standardized data on gender disparities using a scale from 0 to 1 to assess gender inequality.
2. Human Development Index (HDI) Values: Sourced from the UNDP's Human Development reports, using a scale from 0 to 1 to assess a country's development level.
3. Breast Cancer Incidence and Mortality Rates: Acquired from the WHO's Global Health Observatory

These sources are reliable due to their standardized data collection methodologies, transparency in data acquiring processes, and global recognition in health and development statistics (Dieye, 2018).

2.5 Inclusion Criteria:

1. Countries with available data on GII, HDI and Breast cancer mortality and incidence rates for the year 2022
2. Countries representing a diverse range of HDI categories
3. Exclusion of countries with incomplete or unreliable data to maintain data integrity
4. All **female** population data for breast cancer incidence and mortality rates
5. All Age Standardized Rates have been considered for incidence and mortality rates
6. Rates are all standardized per 100,000 people.
7. All values are taken exactly from the databases from sources therefore, rounding and error uncertainty is the same as the original databases.

By adhering to these criteria, the study aims to produce accurate and representative results.

2.6 Ethical Considerations:

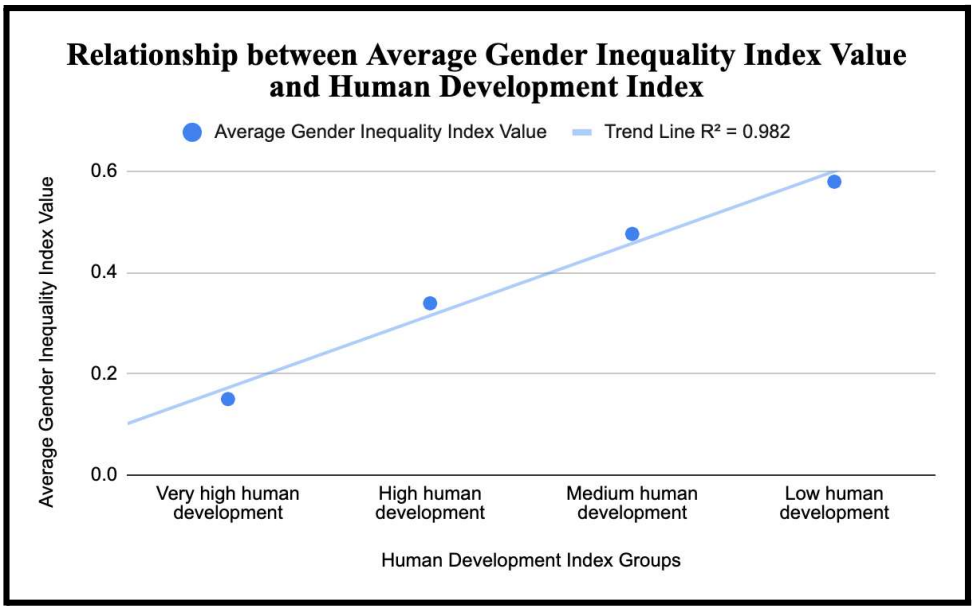
1. As the study involves secondary data analysis, there are no direct safety concerns or undue harm on any participants
2. The research does not involve physical interventions, thus posing no environmental risks

3. Since publically available data is being used, proper citation of data sources, and data usage guidelines set by the respective organizations will be adhered to.

3. Preliminary Investigation

3.1 Ensuring Significant Inverse Relationship between HDI and GII

Graph 1: graphed to show the relationship between HDI and GII values.



The coefficient of determination (R^2) as calculated by Google Spreadsheets is a high 0.982, confirming a strong correlation between HDI and GII, showing that lower HDI values are associated with higher gender inequality. Therefore, it is essential to account for HDI when examining the factors of gender inequality to ensure that variations in GII are not confounded by a country's overall development status. By comparing countries across various development levels, the study can better determine whether gender disparities persist beyond general development differences, offering clearer insights into the role of gender inequality in healthcare outcomes.

4. Main Investigation - Correlation between GII and CFR

4.1 Calculating Case-Fatality Rates using Breast Cancer Incidence and Mortality Rates

To understand the relationship between GII and CFR, it is necessary to calculate CFR using breast cancer incidence and mortality rates data taken from WHO as provided in *Appendix A*.

Using the data from *Appendix A*, the following formula can be used to calculate Case-fatality rate. This will measure the severity of breast cancer by indicating the proportion of people diagnosed with the condition who die from it. Hence, a high CFR suggests poor access to medical care, late-stage diagnosis, or inadequate treatment which may be linked to systemic issues like gender inequality, especially since breast cancer predominantly affects women.

Formula:

$$Case - Fatality\ Rate = \frac{ASR\ Mortality\ Rate\ in\ a\ given\ area\ in\ 2022}{ASR\ Incidence\ Rate\ in\ a\ given\ area\ in\ 2022} \times 100$$

ASR Mortality and Incidence Rates are age-standardized rates and are measured per 100,000 people. This calculated case-fatality rate value will be expressed as a percentage, indicating the proportion of individuals who die from breast cancer.

Sample Calculation with Slovenia:

$$Case - Fatality\ Rate = \frac{ASR\ Mortality\ Rate\ in\ a\ given\ area\ in\ 2022}{ASR\ Incidence\ Rate\ in\ a\ given\ area\ in\ 2022} \times 100$$

$$Case - Fatality\ Rate = \frac{15.0}{82.3} \times 100$$

$$Case - Fatality\ Rate = 18.22600243$$

Hence, Slovenia's Case-Fatality rate due to Breast Cancer is 18.2% (3 sig figs).

Note that all values in the original WHO database are rounded to 3 significant figures. For consistency, I will round the calculated values to 3 significant figures, however the original calculations done by Google Spreadsheets will be using the unrounded values. The Case-fatality rates for all 20 countries were calculated through Google Spreadsheets and values are shown in *Table 3*.

Table 3 **-** All calculations of CFR from Google Spreadsheets

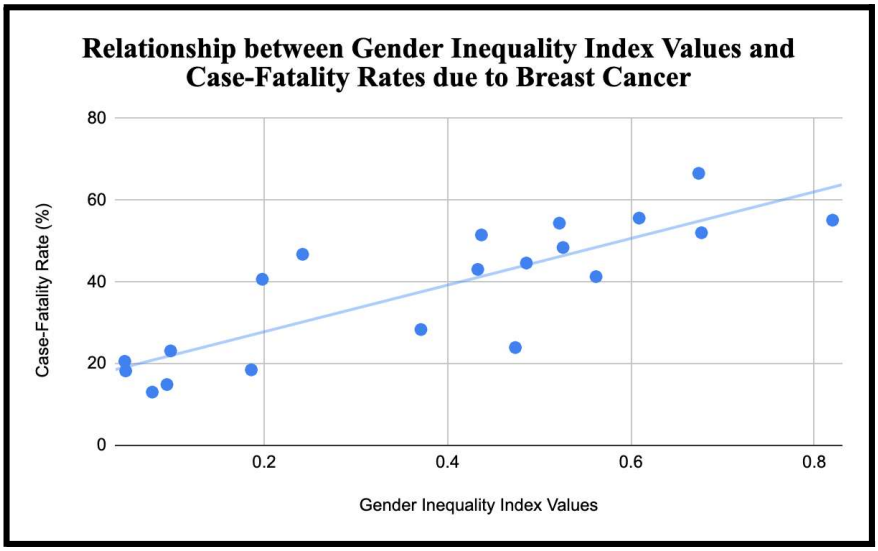
Country	GII value	Case-Fatality Rate due to Breast Cancer of women in 2022 (%)	CFR (%) Rounded to 3 sig figs
Slovenia	0.049	18.22600243	18.2
Japan	0.078	13.03763441	13.0
United Kingdom	0.094	14.89361702	14.9
Austria	0.048	20.57553957	20.6
Lithuania	0.098	23.12599681	23.1
Armenia	0.198	40.65656566	40.7
Dominican Republic	0.433	43.07116105	43.1
Ecuador	0.371	28.35443038	28.4
Uzbekistan	0.242	46.76258993	46.8
China	0.186	18.48484848	18.5

Cambodia	0.486	44.62151394	44.6
Guatemala	0.474	23.94366197	23.9
India	0.437	51.5037594	51.5
Zambia	0.526	48.43049327	48.4
Iraq	0.562	41.30052724	41.3
Somalia	0.674	66.58031088	66.6
Yemen	0.82	55.11811024	55.1
Nigeria	0.677	52.03883495	52.0
Pakistan	0.522	54.38596491	54.4
Guinea	0.609	55.625	55.6

4.2 Graphing Correlation Between GII and CFR

With the case-fatality rates calculated, we can now explore their relationship with gender inequality. Since CFR reflects healthcare accessibility, early detection, and treatment quality, analyzing its correlation with GII will help determine whether disparities in gender equity contribute to differences in breast cancer outcomes. This analysis will provide insights into how societal factors influence disease severity and survival rates.

Graph 2: The relationship between the GII and CFR



A scatter plot was created to visually assess the relationship between GII and CFR. The trendline indicates a linear relationship, with minimal outliers, hence a Pearson's correlation can be used to quantify the strength and direction of this relationship; providing a numerical measure of how gender inequality may influence breast cancer case-fatality rates (Interpreting the Pearson Coefficient).

4.3 Pearson Correlation Coefficient

The **Pearson correlation coefficient (r)** is calculated using the formula:

$$r = \frac{n(\sum xy) - (\sum x)(\sum y)}{\sqrt{[\, n\sum x^2 - (\sum x)^2]\,[\, n\sum y^2 - (\sum y)^2]}}$$

Where:

- **X** = First variable (**GII)**
- **Y** = Second variable [**CFR (%)**]
- **n** = Number of data points (20 countries)
- ∑**X** = Sum of all values in **X**
- ∑**Y** = Sum of all values in **Y**
- ∑**XY** = Sum of the product of each **X** and **Y**
- ∑**X²** = Sum of squared values of **X**
- ∑**Y²** = Sum of squared values of **Y**

$$r = \frac{20(350.3332182) - (7.584)(760.7365625)}{\sqrt{[(20)(3.959454) - (7.584)^2][(20)(34021.85581) - (760.7365625)^2]}}$$

$$r = \frac{1237.238274}{1484.7266538}$$

$$r = 0.83331047559$$

$$r = 0.833\ (rounded\ to\ 3\ sig\ figs)$$

A Pearson's correlation coefficient of r = 0.833 suggests a strong positive relationship between GII and Case-Fatality Rate for breast cancer. Since the correlation is positive and close to 1, this indicates that as gender inequality increases, the case-fatality rate also tends to rise. As this correlation is above 0.8, this suggests that this trend is consistent across the countries analyzed, highlighting the potential influence of gender disparities on access to healthcare, early detection, and treatment outcomes for breast cancer.

4.4 Statistical Significance Analysis

While the Pearson correlation coefficient (r = 0.833) suggests a strong relationship between GII and Case Fatality Rate, it is essential to determine whether this correlation is statistically significant or if it could have occurred by chance. To achieve this, the p-value will be calculated. The p-value helps assess the reliability of the correlation by indicating whether the observed relationship is likely to exist in the larger population, rather than just in the selected sample of countries. A low p-value (typically below 0.05) would suggest that the correlation is statistically significant, meaning there is strong evidence that higher gender inequality is associated with higher case-fatality rates in breast cancer cases. If the p-value is high, it would suggest that the correlation could have occurred due to random variation. This test was conducted using an online calculator, giving a p-value of <0.0001 as shown in *Appendix B*. This indicates that the correlation between GII and Case-Fatality Rate due to breast cancer is highly statistically significant, with the likelihood of it occurring due to chance being less than 0.01%. This provides evidence that higher gender inequality is strongly associated with higher case-fatality rates. Since the correlation is both strong (r = 0.833) and statistically significant (p < 0.0001), no further statistical tests are necessary. The findings suggest a meaningful relationship, supporting my research hypothesis that countries with higher GII values will exhibit higher Breast Cancer Case-Fatality rates.

5. Evaluation

5.1 Implications of Findings

The strong correlation between GII and Case-Fatality Rate due to breast cancer suggests that systemic gender disparities in healthcare access, awareness, and treatment significantly impact survival rates. Countries with higher gender inequality may face barriers such as limited access to early screening, delayed diagnosis, and inadequate treatment, leading to higher mortality despite similar incidence rates. These findings emphasize the need for policy interventions aimed at reducing gender-based disparities in healthcare, such as improving access to cancer screenings, increasing healthcare funding for women's health services, and addressing socioeconomic factors that limit healthcare access. Furthermore, the statistical significance of the results indicates that addressing gender inequality could play a crucial role in improving cancer survival rates, reinforcing the need for global health organizations and policymakers to prioritize gender equity in medical research and public health strategies.

5.2 Limitations and Modifications for Further Research

Table 4: Limitations and Modifications explained.

Limitation	**Explanation**	**Modification**
Use of National-level data	National averages may not reflect regional disparities in gender inequality and healthcare access. For example, rural areas often experience higher gender inequality and poorer healthcare access than urban regions, meaning that national averages may not reflect the full scope of the issue.	Use subnational data (regional/provincial) to analyze differences in more areas within the country itself

Variability in data collection methods	Some countries may have incomplete cancer registries or underreported breast cancer cases and deaths. The UNDP and WHO use data from private research facilities as well as government databases that could potentially pose a threat of bias within the collection methods.	Cross-checking the data by using multiple sources might be a better method of data collection, however due to the lack of data available online, this modification is not as feasible.
Lack of causal evidence	Correlation does not indicate causation; other variables may mediate the relationship	Conducting longitudinal studies to track changes in gender inequality and breast cancer outcomes over time, will better enhance the study to focus on changes to isolate for gender inequality as a cause. Follow-up study could examine how specific components of GII (e.g., female education levels or labor force participation) influence early detection rates, treatment delays, or survival outcomes.
Focus only on breast cancer within the female population.	As this study does not allow for comparisons with other populations, it cannot conclude that women are the only group impacted by gender inequality.	Expanding the analysis to include male populations and male-specific diseases would provide a more comprehensive understanding of how gender inequality influences health outcomes. This broader approach would offer deeper insights into the influence of gender disparities within healthcare systems across different countries.

6. Conclusion

This investigation explores how gender inequality affects breast cancer case-fatality rates across countries aiming to understand how systemic gender disparities impact women's access to healthcare, early diagnosis, and treatment. The findings support the hypothesis, confirming that countries with higher levels of gender inequality (lower GII scores) tend to have worse breast cancer survival rates (High CFR). This correlation highlights how restricted access to timely diagnosis, quality treatment, and comprehensive healthcare services in these countries directly impacts women's chances of survival. The study builds on previous research by using recent data to reaffirm the ongoing relevance of this issue. Thus highlighting the importance of improving healthcare access and promoting gender equity on a global scale. Gender inequality is not just a matter of fairness, but a life-and-death issue, particularly when it comes to health outcomes. In countries with high gender inequality, women often face barriers to essential healthcare services. These disparities contribute to higher case-fatality rates for breast cancer, as women in such regions may not receive timely diagnosis or may face economic and social obstacles that prevent them from accessing the best care.

Additionally, policymakers should prioritize equitable healthcare access, especially in regions with pronounced gender disparities. Promoting systemic change to eliminate these barriers will significantly improve survival rates for diseases like breast cancer and contribute to better health outcomes for women worldwide. Addressing gender inequality requires both systemic change and societal shifts, ensuring that all women have equal access to the resources and support they need for better health outcomes. By reducing these disparities, we can make significant strides in increasing survival rates for diseases like breast cancer, ultimately promoting a healthier and more equitable world for women globally.

References

"Breast Cancer." *Cleveland Clinic*, 18 Feb. 2025, my.clevelandclinic.org/health/diseases/3986-breast-cancer. Accessed 23 Mar. 2025.

Breast Cancer Types. (n.d.). Retrieved from https://www.cancercarebrevard.com/breast-cancer/types

Canadian Cancer Society / Société canadienne du cancer. (n.d.). Types of tumours. Retrieved from https://cancer.ca/en/cancer-information/what-is-cancer/types-of-tumours

Casaubon, Jesse T. "BRCA1 and BRCA2 Mutations." *StatPearls [Internet].*, U.S. National Library of Medicine, 23 July 2023, www.ncbi.nlm.nih.gov/books/NBK470239/. Accessed 23 Mar. 2025.

"Human Development Index." Nations, United. *Human Development Reports*, 27 Nov. 2024, hdr.undp.org/data-center/human-development-index#/indicies/HDI. Accessed 23 Mar. 2025.

"Interpreting the Pearson Coefficient." *OPEX Resources*, 14 May 2019, opexresources.com/interpreting-pearson-coefficient/#:~:text=The%20Pearson%20coefficient%20helps%20to,be%20interpreted%20together%2C%20not%20individually. Accessed 23 Mar. 2025.

Kavousi, S., Maharlouei, N., Rezvani, A., Akbari Aliabad, H., & Molavi Vardanjani, H. (2024). Worldwide association of the gender inequality with the incidence and mortality of cervical, ovarian, endometrial, and breast cancers. *SSM - population health*, *25*, 101613. https://doi.org/10.1016/j.ssmph.2024.101613

Merriam-Webster, MORTALITY RATE Definition & Meaning. (n.d.). Retrieved from https://www.merriam-webster.com/dictionary/mortality%20rate

Nations, United. "Gender Inequality Index." *Human Development Reports*, 27 Nov. 2024, hdr.undp.org/data-center/thematic-composite-indices/gender-inequality-index#/indicies/GII. Accessed 23 Mar. 2025.

"Overview of Cancer - Cancer." *MSD Manual Consumer Version*, www.msdmanuals.com/home/cancer/overview-of-cancer/overview-of-cancer. Accessed 23 Mar. 2025.

"Poorly Differentiated Adenocarcinoma". The Armed Forced Institute of Pathology. http://commons.wikimedia.org/wiki/File:Poorly_differentiated_(solid)_adenocarcinoma_of_the_lung.jpg by Public Domain

Says:, M. N., says:, M. L., & says:, E. (2016). Dysplasia & the Difference between Benign and Malignant - Stomp On Step1. Retrieved from https://www.stomponstep1.com/dysplasia-difference-between-benign-and-malignant/

“Understanding the Gender Inequality Index (GII) and Its Impact " Gender Studies. (2025). Retrieved from https://gender.study/issues-of-gender-and-development/gender-inequality-index-impact/#comparing-gii-with-other-indices

Wheel of Names, wheelofnames.com/. Accessed 23 Mar. 2025.

Abdoulaye Mar Dieye. “UNDP as ‘Knowledge Frontier.’” *UNDP*, 22 Mar. 2018, www.undp.org/blog/undp-knowledge-frontier#:~:text=The%20report%20identifies%20three%20reasons,income%20or%20crisis%2Daffected%20countries. Accessed 23 Mar. 2025.

William F. Anderson et al. Male Breast Cancer: A Population-Based Comparison With Female Breast Cancer. *JCO* 28, 232-239(2010). DOI:10.1200/JCO.2009.23.8162

APPENDIX

Appendix A: breast cancer incidence and mortality rates data taken from WHO

Alpha-3 coc	Cancer cod	Population	Country	Label	Sex	Number	95% UI low	95% UI high	Number	ASR (Worlc	Crude rate	Cumulative
AFG	20	004	4	Afghanistar	2	1960	1296	2964	1960	17.9	9.9	2.0
ALB	20	008	8	Albania	2	407	341	486	407	14.5	28.9	1.7
DZA	20	012	12	Algeria	2	4893	4825	4962	4893	20.8	21.8	2.2
AGO	20	024	24	Angola	2	1333	1302	1364	1333	14.3	7.5	1.6
AZE	20	031	31	Azerbaijan	2	794	666	946	794	11.8	15.4	1.3
ARG	20	032	32	Argentina	2	6436	6147	6739	6436	17.6	27.3	1.9
AUS	20	036	36	Australia	2	3393	3188	3611	3393	12.3	25.9	1.3
AUT	20	040	40	Austria	2	1789	1655	1933	1789	14.3	39.0	1.6
BHS	20	044	44	Bahamas	2	87	54	141	87	31.7	42.3	3.3
BHR	20	048	48	Bahrain	2	96	63	147	96	19.7	15.3	2.1
BGD	20	050	50	Bangladesh	2	6162	6144	6180	6162	7.6	7.4	0.81
ARM	20	051	51	Armenia	2	453	381	539	453	16.1	28.8	1.9
BRB	20	052	52	Barbados	2	88	54	145	88	29.8	59.3	3.2
BEL	20	056	56	Belgium	2	2324	2173	2486	2324	14.2	39.5	1.5
BTN	20	064	64	Bhutan	2	8	8	8	8	2.3	2.2	0.28
BOL	20	068	68	Bolivia	2	514	416	635	514	7.5	8.6	0.69
BIH	20	070	70	Bosnia Her	2	564	514	619	564	15.0	34.0	1.7
BWA	20	072	72	Botswana	2	91	81	102	91	8.3	7.2	0.89
BRA	20	076	76	Brazil	2	22189	21669	22722	22189	13.9	20.2	1.5
BLZ	20	084	84	Belize	2	21	9	52	21	11.7	10.1	1.3
SLB	20	090	90	Solomon Is	2	51	46	56	51	20.4	14.4	2.2
BRN	20	096	96	Brunei Dar	2	35	18	67	35	14.3	16.3	1.7
BGR	20	100	100	Bulgaria	2	1399	1243	1575	1399	15.5	39.7	1.7
MMR	20	104	104	Myanmar	2	3271	3249	3293	3271	10.1	11.4	1.1
BDI	20	108	108	Burundi	2	513	461	571	513	15.7	8.1	1.7
BLR	20	112	112	Belarus	2	1384	1297	1476	1384	13.3	27.5	1.6
KHM	20	116	116	Cambodia	2	917	911	923	917	11.2	10.4	1.1
CMR	20	120	120	Cameroon	2	2285	1879	2779	2285	27.4	16.4	3.0
CAN	20	124	124	Canada	2	6827	6619	7042	6827	13.4	35.3	1.2
CPV	20	132	132	Cape Verde	2	23	10	54	23	7.8	8.1	0.78
CAF	20	140	140	Central Afri	2	376	315	449	376	25.3	14.9	2.7
LKA	20	144	144	Sri Lanka	2	1991	1931	2053	1991	11.2	17.7	1.3
TCD	20	148	148	Chad	2	446	420	474	446	8.8	5.1	0.88
CHL	20	152	152	Chile	2	1775	1626	1937	1775	10.3	18.2	1.1
CHN	20	156	160	China	2	74986	72510	77546	74986	6.1	10.9	0.67
COL	20	170	170	Colombia	2	4752	4517	5000	4752	13.3	18.1	1.4
COM	20	174	174	Comoros	2	34	32	36	34	11.8	7.6	1.2
COG	20	178	178	Congo, Rep	2	241	218	266	241	12.5	8.3	1.4
COD	20	180	180	Congo, Dem	2	4254	3805	4756	4254	15.6	8.9	1.7
CRI	20	188	188	Costa Rica	2	423	370	483	423	10.6	16.3	1.2
HRV	20	191	191	Croatia	2	612	539	694	612	11.7	29.2	1.4
CUB	20	192	192	Cuba	2	1779	1635	1935	1779	13.9	31.2	1.5
CYP	20	196	196	Cyprus	2	238	191	296	238	18.6	38.9	2.0
CZE	20	203	203	Czechia	2	1709	1595	1831	1709	11.7	31.4	1.3
BEN	20	204	204	Benin	2	734	676	797	734	18.9	11.5	2.2
DNK	20	208	208	Denmark	2	1114	983	1263	1114	14.1	38.0	1.5
DOM	20	214	214	Dominican	2	1457	1318	1611	1457	23.0	26.3	2.4
ECU	20	218	218	Ecuador	2	1154	1032	1291	1154	11.2	12.7	1.2
SLV	20	222	222	El Salvador	2	332	242	455	332	7.8	9.5	0.81
GNQ	20	226	226	Equatorial (	2	87	77	99	87	21.4	13.1	2.2
ETH	20	231	231	Ethiopia	2	9626	8657	10703	9626	24.0	16.0	2.6
ERI	20	232	232	Eritrea	2	291	262	324	291	22.4	15.9	2.4
EST	20	233	233	Estonia	2	267	222	321	267	13.2	38.5	1.5
FJI	20	242	242	Fiji	2	182	143	231	182	38.9	40.5	4.2
FIN	20	246	246	Finland	2	879	799	967	879	11.9	31.2	1.4
FRA	20	250	250	France (me	2	14739	14369	15119	14739	15.8	43.6	1.7
GUF	20	254	254	French Guy	2	24	24	24	24	15.9	15.1	1.5
PYF	20	258	258	French Poly	2	45	45	45	45	23.2	32.1	2.4
DJI	20	262	262	Djibouti	2	102	89	117	102	22.1	21.1	2.4
GAB	20	266	266	Gabon	2	113	103	124	113	13.2	9.9	1.4
GEO	20	268	268	Georgia	2	861	754	983	861	20.6	41.4	2.3
GMB	20	270	270	The Republ	2	50	39	65	50	6.6	3.9	0.62
PSE	20	275	275	Gaza Strip (	2	333	325	341	333	19.7	12.6	2.3
DEU	20	276	276	Germany	2	20601	20086	21129	20601	15.8	48.6	1.7
GHA	20	288	288	Ghana	2	2369	2293	2448	2369	19.3	14.8	2.1
GRC	20	300	300	Greece	2	2431	2252	2624	2431	14.7	46.3	1.6
GLP	20	312	312	France, Gui	2	73	72	74	73	16.7	33.9	1.8

IRL	20	372	372	Ireland	2	883	778	1003	883	17.2	35.0	1.8
ISR	20	376	376	Israel	2	1207	1087	1340	1207	16.2	27.0	1.7
ITA	20	380	380	Italy	2	15455	14975	15950	15455	14.8	50.0	1.5
CIV	20	384	384	Côte d'Ivoir	2	2092	2002	2186	2092	25.4	15.2	2.7
JAM	20	388	388	Jamaica	2	684	558	838	684	35.2	45.5	3.6
JPN	20	392	392	Japan	2	17638	17107	18186	17638	9.7	27.4	1.1
KAZ	20	398	398	Kazakhstan	2	1574	1424	1740	1574	12.3	15.9	1.4
JOR	20	400	400	Jordan	2	802	778	827	802	19.3	15.8	2.1
KEN	20	404	404	Kenya	2	3398	3308	3490	3398	19.6	12.0	2.2
PRK	20	408	408	Korea (Dem	2	1796	1758	1835	1796	9.8	13.5	1.0
KOR	20	410	410	Republic of	2	2913	2720	3120	2913	5.8	11.4	0.62
KWT	20	414	414	Kuwait	2	255	244	267	255	17.0	15.0	1.7
KGZ	20	417	417	Kyrgyzstan	2	270	223	327	270	8.2	7.9	0.95
LAO	20	418	418	Lao People'	2	384	382	386	384	12.6	10.3	1.4
LBN	20	422	422	Lebanon	2	781	755	808	781	20.4	23.6	2.3
LSO	20	426	426	Lesotho	2	96	75	123	96	9.8	8.7	1.0
LVA	20	428	428	Latvia	2	430	354	523	430	16.3	43.2	1.9
LBR	20	430	430	Liberia	2	351	278	444	351	19.5	13.3	2.1
LBY	20	434	434	Libya	2	460	435	487	460	13.3	13.2	1.4
LTU	20	440	440	Lithuania	2	515	458	579	515	14.5	36.0	1.7
LUX	20	442	442	Luxembour	2	105	73	151	105	15.1	33.1	1.6
MDG	20	450	450	Madagasca	2	1498	1366	1643	1498	16.4	10.3	1.8
MWI	20	454	454	Malawi	2	872	813	936	872	14.8	8.5	1.6
MYS	20	458	458	Malaysia	2	3526	3038	4092	3526	19.3	21.8	2.1
MDV	20	462	462	Maldives	2	26	24	28	26	13.2	12.8	1.5
MLI	20	466	466	Mali	2	1348	1271	1430	1348	23.1	12.6	2.5
MLT	20	470	470	Malta	2	81	56	117	81	13.8	36.6	1.5
MTQ	20	474	474	France, Ma	2	74	73	75	74	16.3	36.6	1.7
MRT	20	478	478	Mauritania	2	315	251	396	315	18.5	12.9	2.0
MUS	20	480	480	Mauritius	2	209	161	271	209	19.0	32.3	2.1
MEX	20	484	484	Mexico	2	8195	7873	8530	8195	10.3	12.2	1.2
MNG	20	496	496	Mongolia	2	56	42	75	56	3.2	3.3	0.33
MDA	20	498	498	Moldova	2	675	612	745	675	17.5	32.2	2.1
MNE	20	499	499	Montenegr	2	154	126	189	154	23.3	48.5	2.6
MAR	20	504	504	Morocco	2	4044	3988	4100	4044	18.1	21.3	2.0
MOZ	20	508	508	Mozambiq	2	1207	1132	1287	1207	12.0	7.1	1.2
OMN	20	512	512	Oman	2	199	184	215	199	13.1	10.9	1.4
NAM	20	516	516	Namibia	2	227	209	247	227	22.5	16.7	2.5
NPL	20	524	524	Nepal	2	1149	1146	1152	1149	7.6	7.1	0.78
NLD	20	528	528	The Nether	2	3269	3076	3474	3269	14.5	37.9	1.6
NCL	20	540	540	New Caled	2	35	35	35	35	16.8	24.2	1.7
VUT	20	548	548	Vanuatu	2	11	10	12	11	8.9	6.9	0.74
NZL	20	554	554	New Zealar	2	759	665	867	759	15.5	30.5	1.7
NIC	20	558	558	Nicaragua	2	366	310	433	366	10.6	10.7	1.2
NER	20	562	562	Niger	2	1354	1262	1453	1354	19.0	10.5	2.0
NGA	20	566	566	Nigeria	2	16332	16114	16553	16332	26.8	15.3	2.9
NOR	20	578	578	Norway	2	765	660	887	765	11.0	28.1	1.1
PAK	20	586	586	Pakistan	2	15552	15333	15774	15552	18.6	14.0	2.1
PAN	20	591	591	Panama	2	297	240	368	297	10.5	13.4	1.1
PNG	20	598	598	Papua New	2	900	787	1029	900	26.7	19.8	2.8
PRY	20	600	600	Paraguay	2	608	526	703	608	16.9	16.9	1.8
PER	20	604	604	Peru	2	1951	1798	2117	1951	9.4	11.5	1.0
PHL	20	608	608	Philippines	2	11857	11735	11981	11857	21.5	21.2	2.3
POL	20	616	616	Poland	2	8723	8357	9105	8723	17.4	44.8	1.9
PRT	20	620	620	Portugal	2	2211	2049	2386	2211	14.5	41.4	1.5
GNB	20	624	624	Guinea-Bis	2	109	91	131	109	16.7	10.4	1.8
TLS	20	626	626	Timor-Leste	2	49	47	51	49	10.2	7.2	1.1
PRI	20	630	630	Puerto Rico	2	504	410	620	504	14.3	33.8	1.6
QAT	20	634	634	Qatar	2	62	57	67	62	11.4	8.2	1.3
REU	20	638	638	France, La f	2	90	90	90	90	12.1	19.2	1.2
ROU	20	642	642	Romania	2	3877	3626	4145	3877	16.5	39.6	1.9
RUS	20	643	643	Russian Fed	2	22115	21502	22745	22115	13.6	28.3	1.6
RWA	20	646	646	Rwanda	2	401	371	433	401	8.4	5.8	0.90
LCA	20	662	662	Saint Lucia	2	23	10	55	23	16.4	24.5	1.7
STP	20	678	678	Sao Tome a	2	7	7	7	7	9.6	6.2	1.3
SAU	20	682	682	Saudi Arabi	2	1046	1023	1069	1046	7.6	6.9	0.82
SEN	20	686	686	Senegal	2	976	807	1181	976	16.4	10.8	1.8
SRB	20	688	688	Serbia	2	1845	1708	1992	1845	18.5	41.8	2.1
SLE	20	694	694	Sierra Leon	2	118	112	124	118	4.2	2.8	0.45
SGP	20	702	702	Singapore	2	984	827	1171	984	17.8	34.7	2.0
SVK	20	703	703	Slovakia	2	1241	1110	1388	1241	18.1	44.3	2.0
VNM	20	704	704	Viet Nam	2	10008	9884	10134	10008	14.7	20.2	1.6
SVN	20	705	705	Slovenia	2	470	397	556	470	15.0	45.1	1.6
SOM	20	706	706	Somalia	2	1165	1063	1277	1165	25.7	13.8	2.8
ZAF	20	710	710	South Afric	2	5232	4965	5514	5232	17.0	17.0	1.6
ZWE	20	716	716	Zimbabwe	2	915	864	969	915	18.6	11.4	2.1
ESP	20	724	724	Spain	2	6747	6490	7014	6747	10.6	28.4	1.1
SSD	20	728	728	South Suda	2	657	574	752	657	17.6	11.3	1.9
SDN	20	729	729	Sudan	2	3243	3147	3342	3243	20.7	14.1	2.1
SUR	20	740	740	Suriname	2	53	29	97	53	14.4	17.8	1.5

ZAF	20	710	710	South Afric	2	5232	4965	5514	5232	17.0	17.0	1.6
ZWE	20	716	716	Zimbabwe	2	915	864	969	915	18.6	11.4	2.1
ESP	20	724	724	Spain	2	6747	6490	7014	6747	10.6	28.4	1.1
SSD	20	728	728	South Suda	2	657	574	752	657	17.6	11.3	1.9
SDN	20	729	729	Sudan	2	3243	3147	3342	3243	20.7	14.1	2.1
SUR	20	740	740	Suriname	2	53	29	97	53	14.4	17.8	1.5
SWZ	20	748	748	Eswatini	2	47	38	58	47	11.3	7.8	1.1
SWE	20	752	752	Sweden	2	1535	1402	1680	1535	11.9	30.1	1.3
CHE	20	756	756	Switzerlanc	2	1541	1394	1703	1541	12.4	34.9	1.3
SYR	20	760	760	Syrian Arab	2	1781	1622	1955	1781	20.9	18.4	2.3
TJK	20	762	762	Tajikistan	2	283	233	344	283	7.4	5.7	0.81
THA	20	764	764	Thailand	2	7599	7505	7695	7599	11.8	21.1	1.3
TGO	20	768	768	Togo	2	524	481	571	524	18.1	12.0	2.0
TTO	20	780	780	Trinidad an	2	255	197	330	255	22.1	35.8	2.3
ARE	20	784	784	United Arat	2	253	245	261	253	15.9	8.0	1.7
TUN	20	788	788	Tunisia	2	901	881	922	901	10.9	14.8	1.1
TUR	20	792	792	Türkiye	2	7360	6946	7799	7360	12.5	17.0	1.3
TKM	20	795	795	Turkmenist	2	485	254	925	485	15.6	15.4	1.7
UGA	20	800	800	Uganda	2	1560	1489	1635	1560	12.6	6.4	1.4
UKR	20	804	804	Ukraine	2	6613	6171	7087	6613	13.2	28.5	1.6
MKD	20	807	807	North Mace	2	379	281	511	379	19.5	36.4	2.2
EGY	20	818	818	Egypt	2	9596	9464	9730	9596	19.9	18.3	2.1
GBR	20	826	826	United Kinc	2	12122	11723	12534	12122	14.0	35.0	1.5
TZA	20	834	834	Tanzania, U	2	2255	2151	2364	2255	12.9	7.1	1.5
USA	20	840	840	United Stat	2	42900	42296	43513	42900	12.2	25.4	1.3
BFA	20	854	854	Burkina Fas	2	818	799	837	818	13.2	7.4	1.5
URY	20	858	858	Uruguay	2	777	677	892	777	21.6	43.0	2.4
UZB	20	860	860	Uzbekistan	2	2246	2063	2446	2246	13.0	13.0	1.5
VEN	20	862	862	Venezuela	2	2953	2749	3172	2953	16.2	19.9	1.8
WSM	20	882	882	Samoa	2	24	24	24	24	28.1	24.6	3.1
YEM	20	887	887	Yemen	2	1528	1463	1596	1528	14.0	9.9	1.4
ZMB	20	894	894	Zambia	2	507	475	541	507	10.8	5.2	1.2
				Total		665683			665683	12.7	17.0	1.4

Appendix B: p-value test from VassarStats

Data Summary

$\sum X$ =	7.584	$\sum X^2$ =	3.9595
$\sum Y$ =	760.7366	$\sum Y^2$ =	34021.8558
$\sum XY$ =	350.3332		

	X	Y
N	20	
Mean	0.3792	38.0368
Variance	0.057	267.6763
Std.Dev.	0.2388	16.3608
Std.Err.	0.0534	3.6584

r	r^2	Slope	Y Intercept	Std. Err. of Estimate
0.8333	0.6944	57.089189	16.38858	9.2922

t	df	P		
			one-tailed	<.0001
6.4	18		two-tailed	<.0001

0.95 and 0.99 Confidence Intervals for rho

	Lower Limit	Upper Limit
0.95	0.62	0.932
0.99	0.519	0.949

0.95 and 0.99 Confidence Intervals for the Slope of the Regression

	Lower Limit	Upper Limit
0.95	38.2542	75.9242
0.99	31.3808	82.7976