

Infant Mortality Rate and Life Expectancy Across High Income Nations: A Panel Data Analysis

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Abstract:

This paper will investigate the connection of infant mortality rate and life expectancy across the world. Particularly in those countries that are considered to be High Income. It will investigate multiple different variables using an econometric approach to find whether there is a correlation. The data will be collected using WDI and will be using multiple high-income countries from each region of the world. By spreading the data collection across multiple continents, it will allow for multiple variables to account for differences in lifestyle.

JEL Classification: **I10, I18, I19**

Keywords: Infant mortality rate, Life Expectancy

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1.0 INTRODUCTION

Life Expectancy and infant mortality rate are two of the most important factors in the world today. They are often symbolic of the wellness of a nation, and whether that nation has become industrialized. As nations industrialize and become more advanced there should be a rise in the life expectancy for the average occupant of the country; while the infant mortality rate should fall as these other factors are increasing. In high income countries it is possible to look at the manner in which they progressed to become global leaders.

Global powerhouse countries have always supported and helped countries who are still developing. However, looking into how these major countries are able to sustain themselves and continue to grow themselves along with increasing the well being of their citizens is a major question. How are countries able to move themselves forward with continually increasing the life expectancy in their country? As humans around the world continue to live longer than their predecessors, it can only be assumed that children are also healthier and have a lower mortality rate. However, what are the factors that play into this?

Just like in anything that is produced, there must be factors of production. In regards to the “production” of longer lives, and lower infant mortality rates there will be severable variables used in accordance with the study. Studies have shown that infant mortality rate can be influenced negatively by socioeconomic issues in high income countries (Hollowell et al., 2011). It is often said that life expectancy and education go hand in hand with one another. It is most likely the case with infant mortality rates as well, as when the mothers

are better educated, they have a better chance of having a healthy pregnancy and a safe birth of their child (Schell et al., 2007).

This paper was guided by three research objectives that differ from other studies: First it investigates the possibility of a reliance on education to transition into an older society. As societies have advanced one factor has become increasingly evident and this is that education is a crucial piece of the puzzle for all industrializing nations. Without educated people there is simply not enough skilled workers to be able to advance in the necessary fashions.

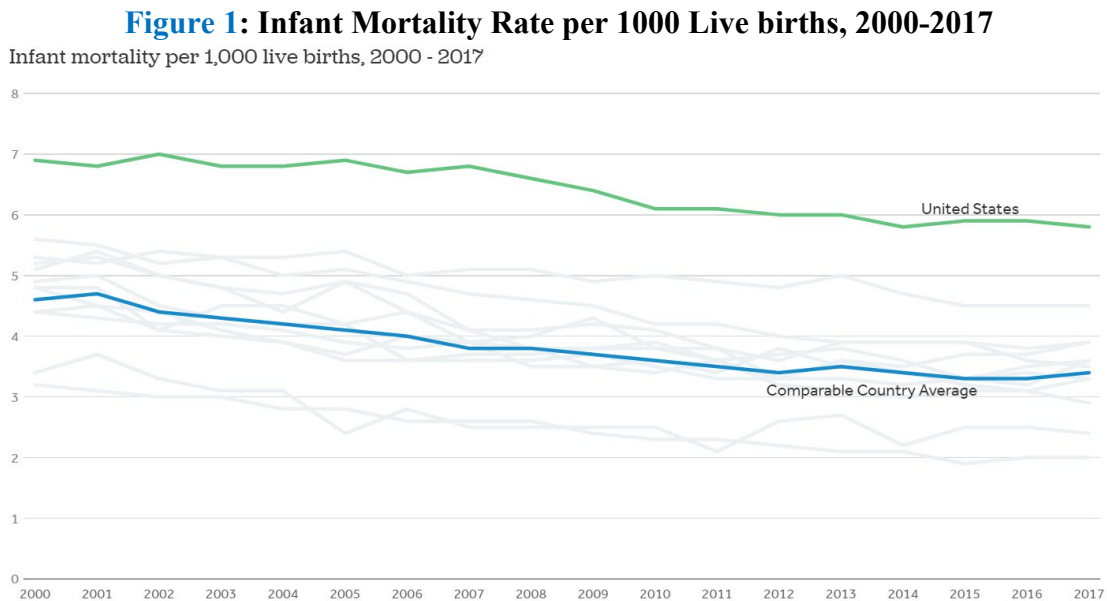
Second, it will investigate the main factors in infant mortality rate and life expectancy. Some of these may be included in other studies but they have not all been done together at the same time. By combining all these variables together for the first time it will be able to give a conclusive answer to whether there is a correlation between these two in high income countries. In many studies the author will look at variables specifically to find the manner in which they effect the outcome. However, in this study the goal is to better comprehend the total impact of all independent variables on the dependent variables.

Thirdly, it investigates whether there are cultural factors depending upon the region that a country is in that can skew or change life expectancy, and infant mortality rates. This can range to include multiple different variables including religion or other beliefs that often change the lifestyle of the participants in these categories. It is the hope that throughout the course of this study, there will be some light shed upon the variance in infant mortality rate and life expectancy of the population in high income countries across the globe.

The rest of the paper is organized as follows: Section 2 gives a description of the trend. Section 3 gives a brief literature review. Section 4 outlines the empirical model, followed by a description of the variables used. Section 5 will describe the empirical results of this study. Finally, followed by a conclusion in section 7,; after that there will be appendices and a bibliography.

2.0 Infant Mortality rate and Life expectancy Across High-Income Nations

Figure 1 shows the United States infant mortality rater per 1000 live births against other countries with comparable statistics. These include being a high-income country in order to account for other issues. As you can see the United States is actually quite a bit higher than most of the comparable countries in this category. However, it is actually declining at a faster rate than many of the other countries included in this study such as Canada, Japan, and other high-income nations around the globe.



Source: Health System Tracker.org

Figure 2 the life expectancy at birth across the 17 countries that have been selected for the study. This data is according to the World Bank's Development Indicators for the year 2015. The United States is actually in the lower portion of the grouping, quite possibly due to lifestyle and other factors of overall health. Countries such as Australia and Japan are the group leaders with their life expectancy at the time of birth ranging from 82- 84 years old.

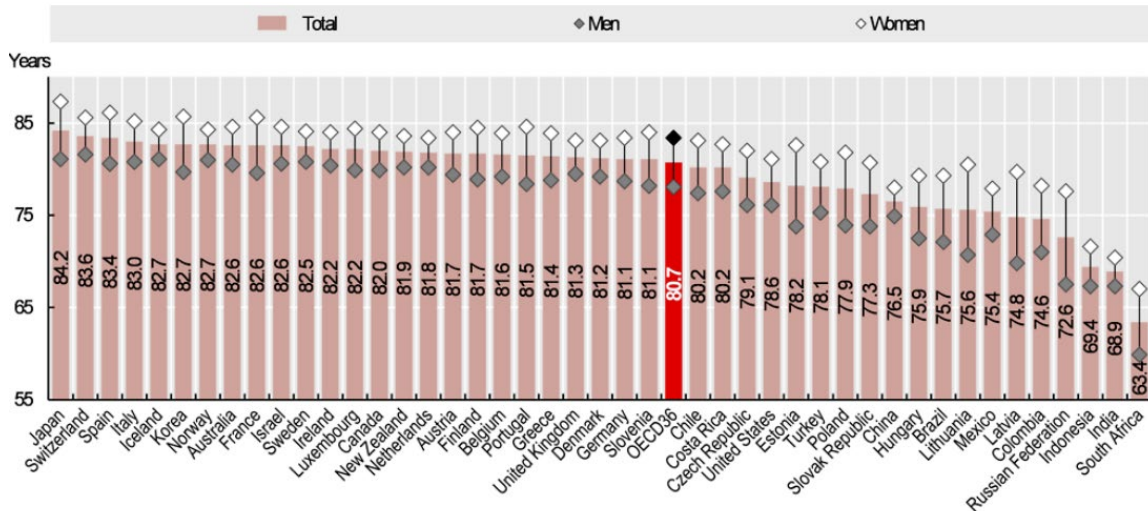
Figure 2: Life Expectancy at time of Birth (total years) in 2015



Source: World Bank Data Bank

Figure 3 further expands upon life expectancy at birth, by showing it across many more countries, and also separates it by sex. As shown in the figure in most countries' women tend to live longer than men do, this can be for a multitude of reasoning. As we move from right to left on the figure we can see that the countries level of wealth tends to decrease and we move from high income to lower income countries.

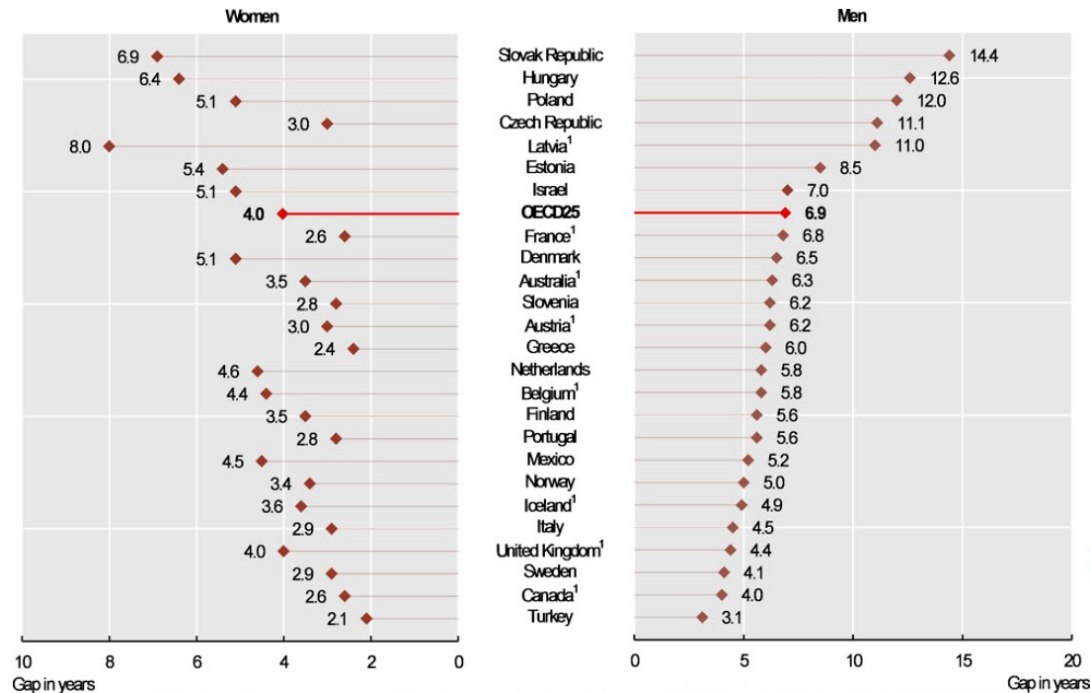
Figure 3 Life Expectancy by Sex



Source: OECD Health at a Glance Indicators

Figure 4 represents the gap that is created in life expectancy by the variable education. This chart shows the gap created between highest and lowest education level for OECD countries and then also separates it by sex. This is one way of looking at multiple different variables interactions all at the same time. Understanding the relationship between education and life expectancy is one of the main goals of this paper and will continue to be investigated throughout the remainder of this paper.

Figure 4: Gap In Life expectancy at age 30 Between Highest and Lowest Education Level and sex



Source: OECD Indicators

3.0 LITERATURE REVIEW

Life expectancy and infant mortality rate are two standards that nearly every country in the world is always trying to improve upon. As human beings, the goal in life is always to be improving the standard of living, how long life is, and the opportunities that are available to future generations. While looking into these two topics there are multiple different variables to consider; current health expenditure per capita is one main variable to be looking at. One such paper that details this greatly is that of Mohan & Mirmirani (2007), through out the course of their paper they discuss in great detail the effects of having a greater health expenditure per capita on life expectancy. The goal is to use some of their methods during this paper to help create an accurate study.

High income nations often have capabilities that other nations do not, with more wealth comes more responsibility though. These countries are considered world leaders and are required to continually raise the bar on how their people live and are treated. With greater national income these countries can constantly update things. Continually improving upon

healthcare systems has shown promise to extending the average age of someone who lives in the country. (Ho & Hendi 2018).

While there are many determinants of infant mortality rate in any country, it is particularly important to investigate certain factors that play a larger role. It is often understood that things such as hygiene, education and access to health care are the main factors in reduction of infant mortality; these are some of the most difficult factors to change in countries. Socioeconomic determinants can be a bit more challenging to understand and to be able to quantify (Schell et. al., 2007) Socioeconomic factors can be crucial in developing nations strive for success, while can be seen as landmarks in the high-income countries' standards of living.

Just because a country is considered high-income does not mean that there will not be plenty of challenges for people to face. Even in high-income nations there can still be an abundance of issues that can affect the infant mortality rate across the nation. Homelessness, domestic violence and substance abuse can all be found in nearly every country in the world. These socioeconomic factors can skew and change infant mortality rates. Factors such as substance abuse can increase the risk of a mother giving birth to her child too early or also have other health repercussions for the child in the future Hollowell. et al, (2011) this further cements the ideology in the paper by (Schell et al., 2007).

Often times people think of the United States as the standard that many other countries are judged upon. However, it is a lesser known fact that the United States actually lacks behind in many categories of life as compared to its' peers in the high-income nations bracket. One of these areas in particular is that the life expectancy in the United States is actually lower than that of many other nations. There can be a multitude of factors that play into this area for the United States, but the singular most glaring would be that of the United States healthcare system. This issue is exacerbated throughout different regions particularly in the Midwest and southeast regions Avendano & Kawachi (2014).

4.0 DATA AND EMPIRICAL METHODOLOGY

4.1 Data

This study uses a time series data on an annual basis starting in 1995 and moving through the year 2018. It includes 17 countries across five separate regions of the world. All data was obtained from World Development Indicators. Since some data was unavailable for certain years for specific countries, that particular category will be omitted from the study for that specific country and that specific year.

Table 1 Summary Statistics

Variable	Observation	Mean	Std. Dev.	Min	Max
IMR	94	4.61	3.33	2.22	6.57
LEB	91	76.3	3.368	74.2	80.1
CH	95	28'785.72	4.473	\$22'461.66	34'768
EA	95	40.40	15.666	39	68
HB	95	8.1	6.2	2.5	14.5
FR	95	1.42	0.319	1.1	2.32
ANI	95	12'560.68	9'346.521	2941	38'861

4.2 Empirical Model

Following the model of Wellington (2014) we have adapted and modified this study to look into determinants of infant mortality rate and life expectancy. The model has been modified by adding different variables, along with using different constraints. This model will be run more than once, once to account for infant mortality rate, and a second time to investigate life expectancy at birth.

The OLS models can be written as follows:

$$IMR_{it} = \beta_0 + \beta_1 FR_{it} + \beta_2 GDP_{it} + \beta_3 BR_{it} + \beta_4 ANI_{it} + \beta_5 CH_{it} + \beta_6 DR_{it} + \beta_7 EA_{it} + \beta_8 HB_{it} + \varepsilon_{it}$$

$$LEB_{it} = \beta_0 + \beta_1 FR_{it} + \beta_2 GDP_{it} + \beta_3 BR_{it} + \beta_4 ANI_{it} + \beta_5 CH_{it} + \beta_6 DR_{it} + \beta_7 EA_{it} \\ + \beta_8 HB_{it} + \varepsilon_{it}$$

The Fixed Effect Models can be written as follows:

$$IMR_{it} = \beta_0 + \beta_1 FR_{it} + \beta_2 GDP_{it} + \beta_3 BR_{it} + \beta_4 ANI_{it} + \beta_5 CH_{it} + \beta_6 DR_{it} + \\ \beta_7 EA_{it} + \beta_8 HB_{it} + \sum_{i=9}^{26} \beta_i \delta_i + \varepsilon_{it}$$

$$LEB_{it} = +\beta_0 + \beta_1 FR_{it} + \beta_2 GDP_{it} + \beta_3 BR_{it} + \beta_4 ANI_{it} + \beta_5 CH_{it} + \beta_6 DR_{it} + \\ \beta_7 EA_{it} + \beta_8 HB_{it} + \sum_{i=9}^{26} \beta_i \delta_i + \varepsilon_{it}$$

The Random Effect Models can be written as follows: $IMR_{it} = \beta_0 + \beta_1 FR_{it} +$

$$\beta_2 GDP_{it} + \beta_3 BR_{it} + \beta_4 ANI_{it} + \beta_5 CH_{it} + \beta_6 DR_{it} + \beta_7 EA_{it} + \beta_8 HB_{it} + (\alpha_{it} + \varepsilon_{it})$$

$$LEB_{it} = \beta_0 + \beta_1 FR_{it} + \beta_2 GDP_{it} + \beta_3 BR_{it} + \beta_4 ANI_{it} + \beta_5 CH_{it} + \beta_6 DR_{it} + \\ \beta_7 EA_{it} + \beta_8 HB_{it} + (\alpha_{it} + \varepsilon_{it})$$

IMR_{it} is the infant mortality rate per 1'000 live births of country i at year t . It is used as an endogenous variable in these models. It represents the amount of people that are born but die before the age of one. The definition of IMR in this paper is consistent with WDI definition. Multiple studies have looked into the determinants of IMR and how they are correlated to countries over an extended period of time.

LEB_{it} is the life expectancy of a person at the time of birth in country i at year t . Throughout the course of this paper it is used as an endogenous variable in these models listed above. This represents the total life span that is expected of a person at the moment they are born. The definition is consistent with that used by the world development indicators.

The estimation technique found to be of best use and fit with the data was chosen based on Breusch and Pagan's LM test and Hausman's Chi-squared statistics. The FE model was found to be the best specification of the estimation. This is likely because the major downfall for the RE model is correlation between omitted variables.

Independent Variables: The independent variables consist of eight variables obtained from World Development indicators. Appendix A and B provide data source, acronyms, descriptions, expected signs, and justifications for using the variables. First, FR_{it} (Fertility rate of country i at year t) represents the fertility rate or the number of births per woman. This is a necessary variable to include as the toll that is incurred on a woman's body during the process of childbirth could have a significant effect on the health of her child at the time of birth. Second is GDP_{it} (Gross Domestic Product per capita of country i at year t) by including this we are able to see how the country's economic output in relation to the population may be a factor in the infant mortality rate or life expectancy of its citizens. Thirdly, BR_{it} (Birth rate, crude per 1'000 people of country I at year t) This is used to distinguish the difference between still born children and the children that die in infancy (under the age of 1). The fourth independent variable used is ANI_{it} (Adjusted National Income per capita of country i at year t) adjusted national income will be used to give a vastly different view of the net national income divided by the population of the country. The fifth variable being used is CH_{it} (Current health expenditure per capita in current USD of country I at year t) by looking at current health expenditure of a country we can see how much each country is spending on a yearly basis on the healthcare of their citizens, a crucial measure in determining the life expectancy of a citizen along with infant mortality rate. Independent variable number six is DR_{it} (Death rate crude per 1'000 people of country i at year t) death rate takes into the total death rate of country per 1'000 people, this can be used as a measure to influence life expectancy as a whole. The next independent variable used is EA_{it} (Educational attainment, at least bachelors or equivalent, population age 25+, total % cumulative of country i at year t) Education is commonly associated with a longer

life expectancy, and high income nations such as the ones used in this study will often have a higher percentage of the population who is educated to the level of a college bachelors degree. The final independent variable used in this study is \mathbf{HB}_{it} (Hospital beds per 1'000 people of country i at year t) Hospital beds are a good measure of a countries healthcare system and their ability to care for their citizens as a whole.

5.0 EMPIRICAL RESULTS

After running regressions for both independent variables in our fixed, random and pooled models, it was necessary to decide which one was the best fit. Our Hausman test showed us that there was a significant difference between the fixed and random effects estimators. Since the results of this test were significant, we were able to conclude that the fixed effect model was the model that should be used.

The primary goal of this study is to identify a multitude of determinants of infant mortality rate and life expectancy in the selected high-income countries. In Table 2, the regression results of the FE of infant mortality rate for the 17 high income nations selected can be found. Infant Mortality rate was regressed using a multitude of independent variables using panel data analysis. While the signs of the criterion estimate of the exogenous variables were all as predicted. Seven of eight variables were statistically significant at the 10% level, and 4 were statistically significant at minimum the 5% level. The variable found not to be statistically significant was DR.

Table 3 shows the regression results of the fixed effect of life expectancy at time of birth for the 17 selected high-income nations. Five of the eight variables were statistically significant at the 10% level or better. With the exclusion of FR as a depiction of fertility

rate, BR as a depiction of birth rate and DR as a depiction of death rate. All of the variables used followed their expected signs from predictions before the regression.

The estimate of hospital beds per 1000 (HB) was strongly significant (at 1% level) in influencing both infant mortality rate and life expectancy in high-income nations. In the infant mortality rate regression, it was the most significant and in the life expectancy at time of birth regression it was the second most significant, only behind current health expenditure per capita. This is as to be expected hospital beds per 1000 is often considered to be a measure for a countries ability to care for its citizens.

Current health expenditure per capita (CH) is also another major determinant according to regression results from both IMR and LEB, significant (at 5% level) in IMR regression and 1% level in LEB. Looking at the data one is able to see that over the course of time as countries per capita health expenditure increases, the infant mortality rate decreases quickly along with a sharp rise in life expectancy. With countries spending more on the health of their citizens it makes sense that they will not only live longer but have healthier offspring. However, the data shows that it is more likely to increase life expectancy of a person than it is to lower the infant mortality rate.

Educational attainment (EA) is often considered one of the more common determinants of life expectancy across the world. Educational attainment was found to be statistically significant at the 5% level in each of the fixed effect regression. This is as to be expected as more often than not the more highly educated a person is the more likely that they are to take care of their bodies physically. With respect to infant mortality rate, if a mother is more highly educated it is more likely that she will have a healthy pregnancy which results in a decreased infant mortality rate.

Death rate (DR) was the one variable found to be statistically insignificant in either of the regressions. This could possibly be attributed to the fact that random accidents can occur. This was a crude death rate of deaths per 1000, and may not have been as useful of a measure as was anticipated

Fertility rate (FR) was statistically significant in the infant mortality regression (at the 1% level) it was not significant in the life expectancy regression. The toll that is taken on a woman's body during childbirth seems to play more of a role in the health of the child at birth than that of her own life expectancy. By looking through the data, we were able to see a trend in the decrease of fertility rate over time. This may possibly be attributed to the rise in availability of birth contraceptives, or there could be physical attributes developed over time that explain this.

Adjusted net national income and gross domestic product per capita (ANI) and (GDP) were both found to be statistically significant in both studies. High income nations generally have a relatively high output economy which results in more revenue and in each person in the economy having a higher wage. While wage was not included in this study one could argue that it may be a useful indicator of life expectancy to be used in the future. (ANI) and (GDP) were both significant at the 10% level in both regressions.

Table 2: Regression results for the Fixed Effect IMR_{it}

	Coefficient	T-statistics
FR	3.6529*	4.784572

GDP	-2.86*	1.87647
BR	-0.5223*	3.466206
ANI	-.2137*	-4.08438
CH	-.000214**	-1.94508
DR	1.73342	-.442058
EA	-1.11638**	-2.689
HB	-1.22904***	.324483
R ²	.9822	
Adjusted R ²	.979830	
F STAT	405.0856***	

Note: ***, **, and * denotes significance at the 1%, 5%, and 10% respectively.

Table 3: Regression results for Fixed Effect LEB_{it}

	Coefficient	T-Statistics
FR	4.663	85.85026
GDP	-8.8247*	8.54645
BR	-1.077	5.1025
ANI	-7.9905*	-1.003
CH	-.22657***	-2.9606
EA	-1.2973**	3.1027
HB	-1.04162***	-3.2644
R ²	.9743	
Adjusted R ²	.9708	
F STAT	277.78***	

Note: ***, **, and * denotes significance at the 1%, 5%, and 10% respectively.

LIMITATIONS OF THIS STUDY

The Majority of research papers on the determinants of infant mortality rate and life expectancy are not done on high-income nations. This is because the purpose of these studies is often to help developing countries understand what they can change in order to move forward in developing, and to help their citizens. High- income nations generally are

able to take better care of their people and this is why we see most of them as world leaders in life expectancy and in infant mortality rate. While the limited number of studies on high-income nations in particular regards to infant mortality and life expectancy had their drawbacks to this study. Since the focus of this paper is on the time period of 1995-2018 and 17 countries, we used a panel data analysis to provide us with enough observations to make it statistically legitimate research. Another limitation of this study is that not all countries record the data for many different variables, even on the world development indicators site it is difficult to find certain years of data for specific countries.

POLICY IMPLICATIONS

There are several different implications in the real world that could be used from the results of this study. After analyzing the results of the determinants of infant mortality rate and life expectancy, we could possibly use them to advise countries. We might be able to provide developing nations with advice on how to lower the infant mortality rate of their nation, while also improving the life expectancy of their citizens. By improving the quality of their healthcare systems, including the current health expenditure per capita we would be taking steps in the right direction. It may also be used in writing policies to help move towards different forms of healthcare systems in the future. If we were to include the type of healthcare particular countries have, such as the leaders in life expectancy we may see a correlation that suggests moving to that type of system.

7.0 CONCLUSION

Since all of these nations are from different regions, we can assume that they all have different social backgrounds. This includes religion, drinking or smoking tendencies and a

multitude of other factors that could play a background role in influencing the results of this study. These social differences might be a crucial determinant in these studies, however the reporting on the data is too scarce to be able to legitimize it in this study.

The results of the panel data regression were able to provide some useful insight into the differences around the world. With regards to life expectancy as a dependent variable, the number of hospital beds per 1000 was a significant factor. When we are able to fit more people into hospitals around a country it is clear that these patients are receiving higher quality treatment than if they were not admitted to a hospital.

This is clearly evident with the current pandemic going on in the world, COVID-19. Countries that have a lower number of hospitals, and thus hospital beds per 1000 patients have been struggling to keep up with the massive influx of patients. When hospitals are overrun with patients it means that it is more likely that patients will die. Countries with fully operational healthcare systems and more hospital beds per capita are more likely to be able to handle the substantial surges of patients from major issues.

The overall financial status of a country is often looked at by analyzing the countries gross domestic product. The higher it is, generally the better the country is doing as a whole. The GDP of a nation can also be a measure of the quality of life in a country, while there is no true mathematical calculation or standard of what the level of happiness or quality of life is; it may be difficult to quantify. The amount of goods and services produced in a year by a given country may be a measure that can be used in the future if different methods are developed.

It is well known that different countries across the world have different healthcare systems. These different healthcare systems undoubtedly play a role in the life expectancy of

someone and the infant mortality rate of the country. Japan currently is the world leader in life expectancy, and while some of it may be attributed to the lifestyle of the citizens, it is also a world leader in hospital beds per 1000 people. Their ability to take care of the citizens that need to be tended to by medical professionals is truly unrivaled.

While moving through the data from world development indicators we were able to notice several trends. The first being that in the past few decades there has been a decrease in the fertility rate in high income nations. This could most likely be attributed to the introduction and availability of birth contraceptives, as this decrease is nearly perfectly aligned with a decrease in the number of children per woman. In the future we could be looking at the population rate decreasing if this trend moves forward into lower income countries.

This study has created the option in the future for different studies to add onto this one to create an even more in depth look. Possibly in the future we will revisit this study to add different variables and see if they also play a role in the determinants of life expectancy and infant mortality rate. The use of panel data analysis as an econometric method has proven to work well for this type of study and was conducive to the learning experiment.

Appendix A: Variable Description and Data Source

Acronym	Description	Data source
IMR	Infant Mortality Rate (per 1'000 live births)	World Development Indicators
LEB	Life Expectancy at Time of Birth	World Development Indicators
FR	Fertility Rate, total (births per woman)	World Development Indicators
GDP	Gross Domestic Product per capita (current USD)	World Development Indicators

BR	Birth Rate, crude (per 1'000 people)	World Development Indicators
ANI	Adjusted National Income per capita (current USD)	World Development Indicators
CH	Current Health Expenditure per capita (Current USD)	World Development Indicators
DR	Death Rate, crude (per 1'000 people)	World Development Indicators
EA	Educational Attainment, at least a bachelor's or equivalent, population age 25+, total % (cumulative)	World Development Indicators
HB	Hospital Beds (per 1'000 people)	World development Indicators

Appendix B- Variables and Expected Signs and the relationships with Infant Mortality Rate

Acronym	Variable Description	What it captures	Expected sign
FR	Fertility Rate, total (births per woman)	How many children each woman gives birth to since it causes immense stress on the body	+
GDP	Gross Domestic Product per capita (Current USD)	Effect of per Capita GDP on Life Expectancy and Infant Mortality rate	-

BR	Birth rate, crude (per 1'000 people)	Excludes the children that die shortly after birth	-
ANI	Adjusted National Income per capita (Current USD)	They effect of having a higher income on the length of life and the infant mortality rate	-
CH	Current Health Expenditure per capita	The amount of money a country is spending on the health of a single citizen	-
DR	Death Rate, crude (per 1'000 people)	To see if birth rate is larger than death rate in order to see if more people in the country is lowering life expectancy	+
EA	Educational attainment, at least bachelors or equivalent, population age 25+, total % (cumulative)	How the percentage of population with a college degree change Life expectancy and Infant mortality	-
HB	Hospital beds (per 1'000 people)	The ability of a country to care for their population with proper medical ability	-

Appendix C- Variables and Expected Signs and the relationships with Life Expectancy at time of birth

Acronym	Variable Description	What it captures	Expected sign
FR	Fertility Rate, total (births per woman)	How many children each woman gives birth to since it causes immense stress on the body	+
GDP	Gross Domestic Product per capita (Current USD)	Effect of per Capita GDP on Life Expectancy and Infant Mortality rate	-

BR	Birth rate, crude (per 1'000 people)	Excludes the children that die shortly after birth	-
ANI	Adjusted National Income per capita (Current USD)	They effect of having a higher income on the length of life and the infant mortality rate	-
CH	Current Health Expenditure per capita	The amount of money a country is spending on the health of a single citizen	-
DR	Death Rate, crude (per 1'000 people)	To see if birth rate is larger than death rate in order to see if more people in the country is lowering life expectancy	+
EA	Educational attainment, at least bachelors or equivalent, population age 25+, total % (cumulative)	How the percentage of population with a college degree change Life expectancy and Infant mortality	-
HB	Hospital beds (per 1'000 people)	The ability of a country to care for their population with proper medical ability	-

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