THE IMPACT OF ECONOMIC DEVELOPMENT ON HEALTH: A COUNTRY-LEVEL ANALYSIS

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การศึกษานี้ประเมินผลกระทบของการพัฒนาทางเศรษฐกิจต่อสุขภาพ โดยใช้ข้อมูลพาเนลของประเทศทั้งสิ้น 217 ประเทศ แบ่งเป็นประเทศที่มีรายได้สูง 139 ประเทศและประเทศที่มีรายได้ต่ำอีก 78 ประเทศ ในช่วงปี ค.ศ.1995-2018 ตัวแปรตามในการศึกษามีด้วยกันทั้งสิ้น 5 ตัวแปร ได้แก่ อายุคาดเฉลี่ยเมื่อแรกเกิด อัตราการเสียชีวิตของทารก อัตราการเสียชีวิตของเด็กที่มีอายุต่ำกว่า 5 ปี อัตราการมีชีวิตรอดจนถึงอายุ 65 ของประชากรเพศหญิง และอัตราการมีชีวิตรอดจนถึงอายุ 65 ของประชากรเพศชาย การศึกษานี้ใช้วิธีการวิเคราะห์ด้วยสมการถดถอยแบบอิทธิพลตรึงแบบ 2SLS (fixed effects-two stage least squares: FE-2SLS) มีตัวแปรอธิบายที่แทนการพัฒนาทางเศรษฐกิจทั้งสิ้น 2 ตัวแปร ได้แก่ รายได้ประชาชาติต่อหัว และดัชนีจีนี และพิจารณาตัวแปรระดับมหภาคอื่นๆ ที่ได้มีการประเมินไว้แล้วว่าเป็นตัวแปรกำหนดระดับสุขภาพของประชากรที่สำคัญในวรรณกรรม ทั้งนี้ รายได้ประชาชาติต่อหัวและดัชนีจีนีนับเป็นตัวแปรภายในของการศึกษา ผลการศึกษา พบว่า ในประเทศทั้งสองกลุ่ม (รายได้สูงและรายได้ต่ำ) รายได้ประชาชาติต่อหัวมีผลที่เป็นบวกและมีนัยสำคัญทางสถิติต่อสุขภาพ โดยช่วยเพิ่มทั้งอายุคาดเฉลี่ยและอัตราการรอดชีวิตจนถึงอายุ 65 ที่ระดับร้อยละ 5 ส่วนดัชนีจีนีมีนัยสำคัญทางสถิติต่อสุขภาพเฉพาะในประเทศที่มีรายได้ต่ำเท่านั้น ตัวแปรที่สำคัญอื่นๆ รวมถึงการปล่อยก๊าซคาร์บอนไดออกไซด์ และการเติบโตของจำนวนประชากร ก็มีความสำคัญต่อสุขภาพ เช่นเดียวกัน โดยเฉพาะในประเทศที่มีรายได้ต่ำ การศึกษานี้แสดงให้เห็นว่าสุขภาพของประชากรสามารถพัฒนาได้ผ่านการเติบโตทางเศรษฐกิจ และความสำคัญของการพัฒนาทางเศรษฐกิจต่อสุขภาพนั้นมีระดับที่ไม่เท่ากันในกลุ่มประเทศที่มีรายได้แตกต่างกัน

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This study investigates the impact of economic development on health, using a panel of 217 countries (139 high-income and 78 low-income countries for the period 1995-2018). Five dependent variables are included, which are life expectancy at birth, infant mortality, under-5 mortality, survival to age 65 for the female and the male population. The preferred regression method used is fixed effects - two stage least squares modeling (FE-2SLS). The specification includes two measures of economic development, including GDP per capita and the Gini index, as well as other macro-level variables that have been identified as important determinants for population health in the literature. GDP per capita and the Gini index are treated as endogenous variables in the estimation. The results show that, in both country groups, GDP per capita has a positive and statistically significant impact on health, improving life expectancy and survival to age 65 ($P < 0.05$). The Gini coefficient is found to be statistically significant in low-income countries. Other important determinants of population health include CO_2 emissions and population growth, especially in low-income countries. This study shows that population health can be boosted through economic growth and the impact is disproportionately felt across country groups.

Field of Study:	Health Economics and Health Care Management	Student's Signature ....
Academic Year:	2019	Advisor's Signature ....

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Chapter 1 Introduction

1.1. Motivation and Significance

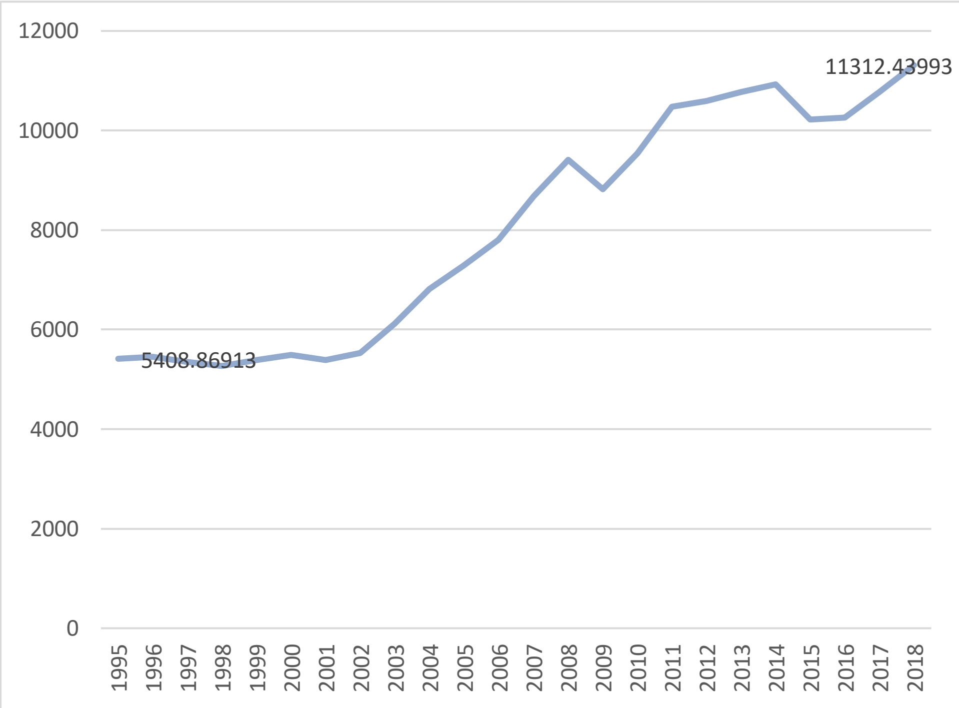
In the WHO Charter, when it was founded in 1946, health is defined as a state of complete physical, mental and social well-being and not merely the absence of disease or infirmity. This represents a departure from the traditional concept of health, which generally refers to the human body without disease.

Economic development is more difficult to define. The definition of economic development has been contested across disciplines. While economists view development primarily in terms of economic growth, sociologists instead emphasize a broader process of change and modernization. Economic development measures national prosperity and is related directly to economic growth. It does not pertain only to GDP increases but refers instead to a broader concept, which also has qualitative dimensions. More specifically, economic development means economic growth in combination with positive changes in certain areas which determine well-being of the people, including, for example, health and education (Greenwood & Holt, 2010).

At the macro level, health is linked to economic development. Globally, as economies expand, living standards continually improve, leading to an improvement in health. With the rapid economic development of countries in the world, the average life expectancy of the population in the world has increased from 48 years in 1950 to 72 years in 2017. There are significant differences in health levels between countries with different economic levels. Health conditions in low-income economies are much worse than in high-income economies. In 2017, for example, life expectancies in advanced economies such as the United States (78.5), France (82.5), Canada (82.2), Australia (82.5), Japan (84.1) are much higher than developing countries such as China (76.5), Russia (72.1), Brazil (75.5), India (69.2), South Africa (63.5). Based on these facts, it can be seen that differences in economic development have an (supposedly positive) impact on health conditions.

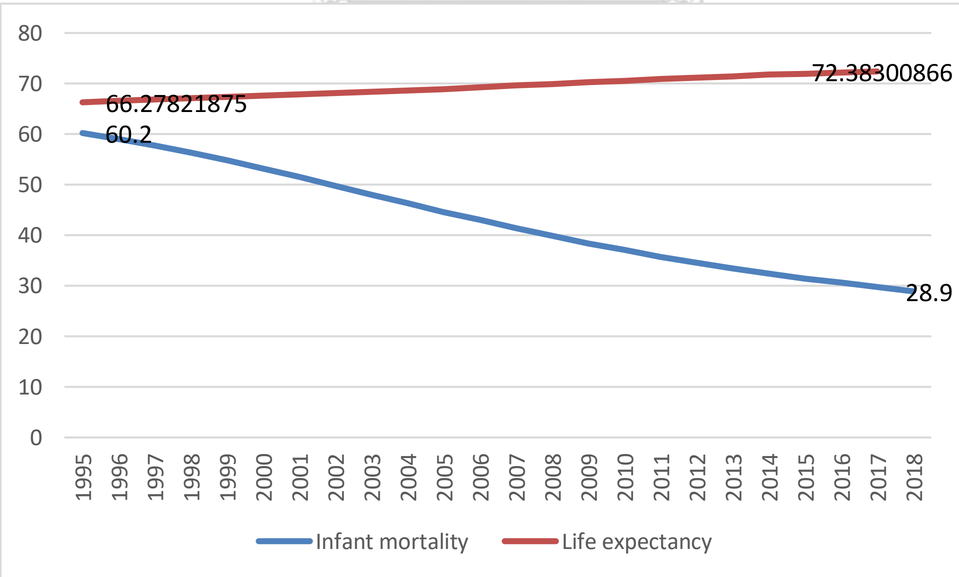
Between 1995 and 2018, the period covered in this study, the world has witnessed both an increase in GDP and in health. According to data from the World Bank, the average per capita GDP in the world was $11312.44 in 2018, but only $5408.87 in 1995 (Figure 1). At the same time, health of the population has also improved. Globally, the average infant mortality rate in 2018 was 28.9% per 1000 live births (Figure 2), with an overall steadily decreasing trend, and the world's average life expectancy reached about 72 years in 2017, with an overall rising trend (Figure 2). These data indicate that health of the population seems to rise with economic development.

Figure 1 GDP per capita 1995-2018 (current US$)



Data Source: The World Development Indicators, World Bank (2020)

Figure 2 Infant Mortality & Life Expectancy 1995-2018



Data Source: The World Development Indicators, World Bank (2020)

There are several mechanisms through which economic development can impact health (Cutler, Deaton, & Lleras-Muney, 2006; Fogel, 1994; Riley, 2001; Sell &

Kunitz, 1986; Amartya Sen, 1990). First, with economic development, people are better able to afford basic necessities for living, including, for example, sufficient food and nutrition, and basic medicine supply. These 'materials' promote living conditions, thus contributing to the improvement of the quality of life and health. Second, economic development is conducive to further health investment, the expansion of health services, and the development of medical and health research, all of which are directly related to the health of population. Finally, economic development indirectly affects population health, through its impact on education. The level of people's education will influence their ability to obtain health care knowledge and to carry out self-care activities, which consequently affect the health condition of the population. The historical decline of mortality (and the increase in life expectancy), which is a widely used measure of population health, has been attributed to factors related to economic and social progress, including the increase in material supply, the improvement of physical infrastructure, increased levels of education, and advances in medical care and medical technologies . If these factors play a crucial part an important role in the improvement of health, then it should be undeniable that the decline in mortality must be associated with economic development.

This study attempts to investigate the impact of economic development on health, using different measures of economic development and health. The use of multiple measures reflects the fact that economic development and health are multi-dimensional concepts.

1.2. Objectives

1.2.1. Primary objective

To investigate the impact of economic development on health.

1.2.2. Secondary objectives

To examine the impact of different indicators of economic development on health at the aggregate level.

To compare the relative strength of different indicators of economic development in explaining health at the aggregate level.

To explore differences in the link between economic development and health among high-income and low-income countries.

1.3. Possible benefits

This study analyzes the impact of different indicators of economic development on health. The relationship between economic development and health is unlikely to be spurious if use different statistical models and different economic and health indicators, the results are consistent.

Also, since this study performs a sub-sample analysis, splitting the sample into high-income and low-income countries, the results of the sub-sample analysis may have an implication on how population health may be improved. For example, if the impact of economic development on health is different between the two groups of countries, then interventions to improve health for countries with different income levels would be different.

Chapter 2 Literature review

At the aggregate level, there seems to be a bidirectional causality in the relationship between economic development and health. In other words, not only does economic development impact health, health also impacts economic development (Cutler et al., 2006; Easterlin, 1999; Riley, 2001; Szreter, 1988, 1999; Szreter & Mooney, 1998). The chapter includes both studies that investigate the impact of health on economic development and those that investigate the effect of economic development on health, but focuses on the latter.

2.1. Impact of health on economic development

The literature on the link between health and economic development or economic growth typically focuses on the impact of health on economic development. Health affects living conditions, influences human capital and consequently impacts the nation's productive capacity and capital accumulation (Hu Hongwei, 2011).

There are theoretical studies of the impact of health on economic development. For example, (Grossman, 1972) studies the influence of economic development on the supply of health services from a micro perspective and points out that health is conducive to the formation of human capital, and the impact of health on a country's economic growth is non-negligible. (Woode, Nourry, & Ventelou, 2014) construct an endogenous growth model, using health, as proxied by health care financing, to explain economic growth. It is shown here that joint health investment by the private and the government sectors can maximize economic growth.

Using the extended Solow growth model and panel data, (Gyimah-Brempong & Wilson, 2004) show that there is a positive relationship between health (as a form of human capital) and the level of investment and the growth rate of per capita income. (Barro, 2013) reveals a positive effect on growth from initial human capital in the form of health. Similarly, (Valeyre et al., 2014) shows that health has an important impact particularly on developing countries, as they are dominated by physical labor, and suggests that health inequality hampers economic development. On the contrary, (Rivera IV & Currais, 1999) find that health affects income growth both positively and significantly. However, the possible existence of endogeneity may bias the observed results. A Hausman test could be performed to confirm that there is a feedback effect between health and income.

Several studies also find that health and education, both of which are different forms of human capital, complement each other and together impact economic growth. Following (Barro, 1996), who was the first person to study the interrelationships between health, education, and material capital, (Van Zon & Muysken, 2005) introduce health indicators into the production function on the supply side, and the utility function on the demand side in order to study the relationship between health investment and economic growth and show that health and education are important to economic growth. Other authors (Blackburn & Cipriani, 2002; Chakraborty, 2004; Ehrlich & Lui, 1991; Kalemli-Ozcan, Ryder, & Weil, 2000) also explored the relationship between health and economic growth through indirect incentives for investment in education, and also found that education and health have powerful complementary effects of economic growth.

There are also studies at the regional and the country (as opposed to cross-country) level. (Glover et al., 2009) point out that an increase in the number and quality of employees in medical and health institutions and an increase in the practice and study in the field of public health can reduce the difference of human capital and reduce the imbalance of economic growth across states in the US. (Kai, 2006) studies the relationship between population health and economic growth in China and draws a conclusion that the health has a significant positive relationship with economic growth. Based on Hunan province in China, (Kun, 2011) finds that the impact of health on economic growth is significant and that the contribution of education to economic growth is overestimated. Finally, (Xuewen, 2014) finds that there is a long-term equilibrium relationship and two-way interaction mechanism between health and economic growth in China.

2.2. Impact of economic development/income on health

Studies directly on the topic of the impact of economic development on health at the country level are sparse. The literature investigates the relationship between health and income or well-being at the country as well as the household level.

There are studies that consider the correlation between health and economic development at the aggregate level. (Summers & Pritchett, 1996), for example, discuss the fact that health indicators in the poorest countries are usually the worst, and suggest that GDP growth has a direct impact on improving health. (Babones & medicine, 2008) argues that population health indicators, e.g. average life expectancy and infant mortality are in fact aggregates of individual-level variables and, if there is a positive relationship between health and income at the individual level, that relationship should carry over to the aggregate level, although, since income inequality in most countries is relatively stable over time, the causality at the aggregate level is difficult to test. (Karlsson, Nilsson, Lyttkens, Leeson, & medicine, 2010) show that although the relationship between income and health overall is positive, there are important differences in the relationship between high-income countries and middle/low-income countries. For example, the form of the relationship between absolute income and health is different. In these two groups of countries, the meaning of family size is different. (Drabo, 2011) found that environmental quality is an important factor influencing population health by income inequality. Finally, (Dorling, Mitchell, & Pearce, 2007) show that there is a strong correlation between income inequality and population health and the relationship is especially strong among younger adults.

There are also studies that explore the impact of economic development on health at the household/individual level. (Frijters, Haisken-DeNew, & Shields, 2005) investigate whether income changes have a causal effect on health satisfaction among East and West Germans. They find a significant positive effect. (Granados & Ionides, 2008) exploit changes in cohort incomes among the elderly to uncover causal effects of permanent income shocks on health and find that income have little effects on a health measures. (Aida et al., 2011) conduct a multivariate meta-regression analysis using nine multilevel cohort studies and find that income inequality impacts self-rated health. Overall, most studies at the household/individual level find that there is a significant and positive relationship between income and health status (Case, Lubotsky, & Paxson, 2002; Deaton, 2002; Fritzell, Nermo, & Lundberg, 2004). However, there are exceptions. For example, (Larrimore, 2011) shows that the relationship remains inconclusive.

The above literature review shows that there is limited research at the macro level on the impact of economic development on health. There are also few articles on the application of panel data. As a result, the use of panel data in this study may be considered a contribution. Also, this study explores a wider range of aggregate-level health measures, including life expectancy, infant mortality, under-5 mortality, female survival to age 65 and male survival to age 65 – contrary to the existing literature which focuses mainly on life expectancy. The choice of other explanatory variables is based on the aggregate-level version of specifications as well as the existing research at the household level, and includes additionally other variables related to economic development, such as education, health-related supply and so on. Summary of the papers discussed in this chapter as well as their specifications are shown in Tables 1-3. Table 2 shows health measures used in these literature. Table 3 shows the specifications in the literature.

Table 1 Summary of existing papers

Author	Data	Model	Outcome	Main findings
Paper 1: (Fritzell et al., 2004)	1996–97 in Swedish, individuals who aged between 25 and 64. (n=7,201)	Logistic Regression, multivariate models	Self-rated health (Good/Poor)	1>. Indicate that a very clear relationship exists between income and health. 2>. Controlling age is very important. Once age is standardized, the link between income and health will become stronger 3>.Individual income and health status of men and women have roughly similar link.
Paper 2: (Lenhart, 2019)	Panel Study of Income Dynamics in US, 1990-2003,	DDD Models	Self-reported health status	1>. By providing evidence for the protective health effects of increased sources of external income on vulnerable groups in the population, the findings of this study provide a new basis for the literature on the relationship between income and health. 2>.The study has shown that the expansion of EITC increases the likelihood of affected household heads being excellent or very good health.
Paper 3: (Adda, Banks, & Von Gaudecker, 2009)	Several cross-sectional serveys (FES, GHS, HSE), 1978-2003, 148,517 individuals	Synthetic Cohort Methodology	Self-reported health	1>.It was found that this income innovation had little effect on a wide range of health measures, but it did lead to an increase in mortality and health behavior risks.
Paper 4: (Granados &	Sweden in the 19th and 20th centuries	Linear regression, spectral analysis,	Mortality rates and life	2>. Economic growth is positively related to health progress in Sweden throughout the 19th century.

Author	Data	Model	Outcome	Main findings
Ionides, 2008)		cross-correlation, and lag regression models.	expectancy	3>.The relationship became weaker over time, and it was completely reversed in the second half of the 20th century, when economic growth had a negative impact on health advancement.
Paper 5: (Larrimore, 2011)	Seven panels of SIPP data from 1992-2005, (omitted 1995)	Standard ordered probit regression	Self-reported health (poor, fair, good, very good, excellent)	1>. There is only limited support for the theory that the relationship between income and morbidity stems from changes in income. 2>. No evidence was found that increasing income can significantly improve self-reported health. 3>. Although increases in income seem to reduce the prevalence of hearing limitations when using corrective measures, these increases did not have a significant impact on most of the other dysfunctions considered here.
Paper 6: (Frijters et al., 2005)	German Socio-Economic Panel (GSOEP),1984-2002 , 46,953 person-year observations on 6198 East Germans, 176,770 person-year observations on 20,617 West Germans.	Fixed-effects; ordinal logit models	Health satisfaction (scale 0-10)	1> Find evidence that changes in income have a significantly positive impact on health satisfaction, but this quantitative impact is small. This is the case in terms of current income and a measure of "permanent" income.
Paper 7:	Cross-sectional	OLS ANOVA	Life	1> There is an unambiguous link between income

Author	Data	Model	Outcome	Main findings
(Babones & medicine, 2008)	analyses, in 1970 and 1995	Models	expectancy, infant mortality, murder rate	inequality and population health at the country level. 2>. The so-called "income illusion" hypothesis is that the correlation between inequality and health is driven by the inequality-income-health communication mechanism.
Paper 8: (Aida et al., 2011)	Cross-sectional studies, Multilevel data (at least two levels including one or more regional variable(s));	Multivariate meta-regression models	Mortality, poor SRH(self-rated health)	1>. Compared with inequality in smaller regions, income inequality at the country level may have a greater impact on the adverse contextual for health, which may be achieved by best reflecting the social stratification in the society.
Paper 9: (Karlsson et al., 2010)	Individuals aged 40-79 in 21 countries in 2006, a total of 21233 respondents	Ordered probit models	Self-assessed general health (1~5), ADLs, healthy life expectancy, life expectancy	1>.In the high-income sample, there is strong evidence that the average income of peers is negatively correlated with health. 2>. In middle/low-income countries, the negative correlation with health is average regional income. 3>. It has evidence that there is a negative correlation between income inequality and individual health in high-income countries.
Paper 10: (Drabo, 2011)	1970-2000, subdivided into 6 periods of 5 years, 90 countries	OLS and 2SLS	Log of under-five survival rate	1>.Environmental degradation can be seen as a channel through which income inequality affects population health. 2>. Income inequality is an important predictor of physical environmental quality in democratic countries, but the signs of impact depend on the relative income elasticity of the median voter's preference for

Author	Data	Model	Outcome	Main findings
				environmental care. 3>. Through an econometric analysis, income inequality has a negative impact on environmental quality, while environmental degradation worsens population health.
Paper 11: (Dorling et al., 2007)	126 countries, in 2002	Linear regression	Mortality	1>. Income inequality seems to have an impact worldwide, especially for young people. 2>. Social inequality seems to have a universal negative effect on health. 3>. Humans are social animals with not well physiological structures and cannot survive in uncooperative environments-especially at the peak of life.
Paper 12: (Barro, 2013)	A panel of roughly100 countries from1960 to 1990.	Three-stage least squares	Life expectancy at birth	1>.It shows in a healthy form the significant positive impact of initial human capital on growth. 2>. The link between overall health status and subsequent economic growth seems to be substantial.
Paper 13: (Rivera IV & Currais, 1999)	cross-country time series data	OLS; Instrumental variables estimation	Health expenditure	1>. Health affects income growth both positively and significantly. 2>. The relationship between income growth and health levels works in both directions.
Paper 14: (Sharma, 2018)	An unbalanced panel of 17 advanced economies, 1870–2013	Fixed effects model; panel GMM	Life expectancy	1>. Life expectancy has positive and statistically significant impact on income as well its growth. 2>. There is very strong link between life expectancy and other population health indicators
Paper 15: (Finlay, 2007)	62 observations; 1960-2000	OLS; 2SLS	Adult Male Mortality	1>. Health does have a positive and significant impact on economic growth.

Author	Data	Model	Outcome	Main findings
				2>. In terms of time, education costs are high, but the rewards are higher.
Paper 16: (Narayan, Narayan, & Mishra, 2010)	annual data, the period 1974–2007	DOLS estimator;	Health expenditure	1>.Although consistent with theory, health, investment, exports, EDRD and R&D has a statistically significant and positive impact on per capita income, while imports have a statistically significant negative impact on per capita income, while education has a statistically insignificant impact on per capita income for group of 5 countries.
Paper 17: (Bhargava, Jamison, Lau, & Murray, 2001)	92 countries at 5-year intervals using the PWT GDP series. (1965-1990)	Random effects models	Adult survival rate	1>. The results show that ASR has a positive impact on the GDP growth rate of low-income countries.

Table 2 Choice of health measures in the literature

Paper	Life expectancy	Infant mortality	Murder	Mortality	Self-rated health	Under-five survival	Health satisfaction	ADLs	Health expenditure	Adult survival
1					√					
2					√					
3					√					
4	√			√						
5					√					
6							√			
7	√	√	√							
8				√	√					
9	√				√			√		
10						√				
11				√						
12	√									
13									√	
14	√									
15				√						
16									√	
17										√

Table 3 Choice of explanatory variables in the literature

Variables	Paper															
	1	2	3	4	5	6	7	8	9	11	12	13	14	15	16	17
Employment status	√															
Open													√			√
Exports															√	
Imports															√	
Tropics														√		√
Malaria prevalence														√		
Rule-of-law index											√					
Terms-of-trade											√					
Democracy index											√					
Social class	√															
Adult male mortality														√		
Adult survival rate																√
Life expectancy											√		√			
Fertility rate											√			√		√
Age	√	√							√							
Education	√		√								√	√	√	√		
Population density	√													√		
Individual earnings	√			√		√			√	√						

Variables	Paper															
	1	2	3	4	5	6	7	8	9	11	12	13	14	15	16	17
Household income	√	√				√										
Gender		√							√							
Race		√														
Married		√				√										
Health limitation		√														
Government consumption ratio											√		√			
Total expenditure			√													
Health expenditure												√			√	
Education expenditure															√	
R&D expenditure															√	
Food expenditure			√													
Cigarettes			√													
Alcohol			√													
Number of children						√										
Has a baby in last 12 months						√										
Separated in last 12 months						√										
Divorced in last 12						√										

Variables	Paper															
	1	**2**	**3**	**4**	**5**	**6**	**7**	**8**	**9**	**11**	**12**	**13**	**14**	**15**	**16**	**17**
months																
Spouse died in last 12 months						√										
Death of other family member in last months						√										
Maternity leave						√										
Fired in last 12 months						√										
Gini coefficient							√	√	√	√						
GDP per capita				√			√		√	√	√			√		
Change of GDP				√												
Inflation				√							√		√			
Investment price														√		
Investment rate												√	√		√	√
Average population size								√								
Population growth												√				

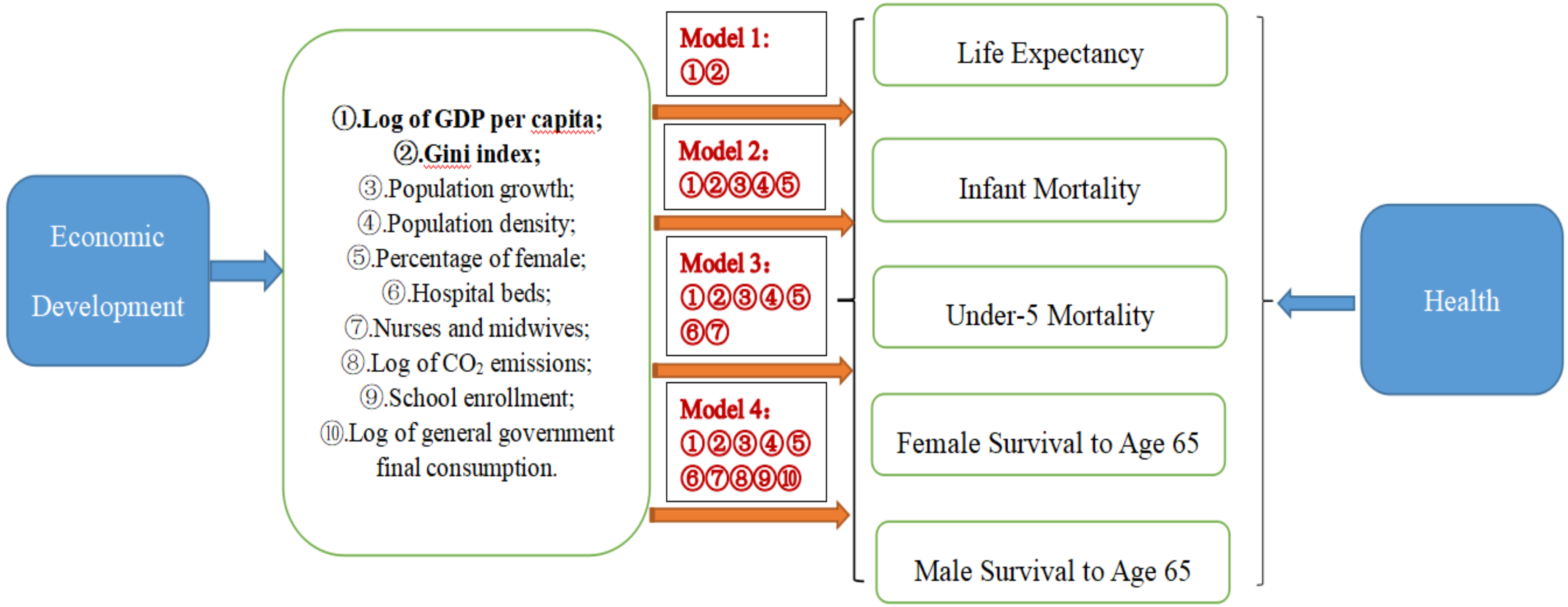
Note: Paper 10 Omitted

Chapter 3 Conceptual Framework

The main objective of this study is to analyze the impact of economic development on health. In this study, aggregate-level/ population-level health indicators represent the outcomes of interest and they include 5 variables: life expectancy, infant mortality, under-5 mortality, female survival to age 65 and male survival to age 65. Economic development, albeit multi-dimensional, is operationalized as the combination of economic growth and inequality and it is measured by GDP per capita and Gini index. The other control variables (which have been identified in the earlier chapter as affecting population health) include population growth, population density, ratio of females, number of hospital beds, number of nurses and midwives, CO_2 emissions, ratio of school enrollment and government consumption (similar to government spending).

This study identifies four different models through which health is affected by economic development. The models, i.e. regression specifications, are shown in the diagram below. GDP per capita and Gini index are the explanatory variables in Model 1. Model 2 includes additionally population characteristics, including population growth, population density and percentage of female population. Model 3 includes additionally health-related supply, namely the number of hospital beds and that of nurses and midwives. Finally, Model 4 is the full model and includes all explanatory variables: which are GDP per capita, Gini index, population growth, population density, percentage of female population, hospital beds, nurses and midwives, CO_2 emissions, school enrollment and general government final consumption.

Figure 3 Conceptual Framework



Chapter 4 Methodology

4.1. Data

The data for this study comes from the World Development Indicators database maintained by the World Bank. The final sample includes panel data from 217 countries for the period of 1995 and 2018. A comparative analysis between high-income and low-income countries is also conducted. Here, countries classified as high-income and upper-middle income countries by the World Bank in 2020 are classified as high-income countries, while those classified as low-income and lower-middle income countries are treated as low-income countries.

4.2. Model

Much of the research on the impact of income or inequality on health focuses on a certain region or country, using cross-sectional or time series data. Panel data used in this study can provide a richer understanding of the relationship between economic development and health, increase the degree of freedom of the model and the validity of parameter estimation.

The regression method used in this study is fixed-effects modeling.

$$H_{it}=\beta_0+\beta_1E_{it}+\beta_2P_{it}+\beta_3M_{it}+\beta_4X_{it}+\mu_i+\varepsilon_{it}$$

Here, H represents health. E represents economic factors, include GDP per capita and Gini index. P represents demographic factors, include population growth, population density and ratio of females. M represents medical factors, include number of hospital beds, number of nurses and midwives. X represents other variables, such as CO_2 emissions, ratio of school enrollment and government consumption.

Economic development may be endogenous. Bloom et al.(2004) found that health has a significant positive feedback effect on economic development, that is, health also contributes to economic growth. In addition, studies have shown that economic growth not only has a unilateral impact on national health, but also affects economic growth by affecting human capital in turn, and there is a feedback mechanism between the two (Liang Run et al., 2015). So in this study, an instrumental variables two-stage-least-squares (2SLS) approach is used to tackle endogeneity of economic development.

Three tests are conducted.

1) Test whether panel data models are appropriate. The Breusch and Pagan LM test for random effects is used.

2) Test whether fixed-effects or random-effects modeling is more appropriate. The Hausman test is used.

3) Test whether the economic development indicators are endogenous. The Hausman test is used.

4.3. Specifications/ Alternative Models

There are five dependent variables: life expectancy at birth, infant mortality, under-5 mortality and survival to age 65 for the female and the male population. These are commonly used heath indicators in many existing studies. The main independent variables representing economic development are GDP per capita (which is an indicator of economic growth) and the Gini Index (which is an indicator of economic inequality). GDP can have a direct impact on health, people can increase their investment in health to improve health; GDP can also have an indirect impact on health by improving diet, increasing nutrition, and improving the quality of life. Overall, GDP is an important indicator of a country's economic situation and is largely linked to health. The Gini index can reflect the difference of income distribution in different countries, capturing the extent of income inequality. Studies have shown that severe income inequality may have a negative impact on population health (Cokley et al., 2006), and this negative effect is mainly manifested in the increased risk of chronic diseases (cardiovascular disease, depression, etc.) among residents in poorer regions (Spencer & development, 2004; Van Doorslaer, Masseria, & Koolman, 2006).

The other explanatory variables are based on the literature review. They include population growth, population density percentage of female, the number of hospital beds and nurses and midwives (per 1000 people), CO_2 emissions, school enrollment (primary) and general government final consumption. (General government final consumption expenditure includes all government current expenditures for purchases of goods and services, including compensation of employees. It also includes most expenditures on national defense and security, but excludes government military expenditures that are part of government capital formation.)

Population growth, population density and the ratio of the female population represent demographic factors. Traditionally, higher population growth is found mainly in countries with lower levels of economic development and it has been shown to lead to shortage of resources and food as well as environmental degradation, all of which may adversely affect health. In addition, environmental pollution caused by high-density population and poor natural conditions affect health of the population. (Spears) (2014) conducts a study on the interactions between sanitation and population density and finds that child health is affected by open defecation externalities in areas where people live more closely together.

Sex ratio is controlled for as it may be important for health. For example. a disproportionately low ratio of males makes it difficult for the male population to marry, leading to a high rate of lifelong non-married men and women and a difficult situation for single elderly people. Unbalanced gender ratio may also lead to a widening gender gap in marriage and an outflow of women from economically disadvantaged areas. Furthermore, gender disorders are also detrimental to mental health (Chunyan, 2013; Renbing, 2002).

Medical factors have a direct relationship with health. They are represented by the number of hospital beds and the number of nurses and midwives (per 1000 people). School enrollment measures the average education level, and as the population becomes more educated, health-related knowledge can be better acquired, leading to changes in health behavior and an improvement in health. For example, an increase in the number of years of schooling for a mother can effectively reduce infant mortality (Jürges, Reinhold, & Salm, 2011). Furthermore, this study chooses to include CO_2 emissions to capture the impact of the environment on health. It is well known that environmental problems impact health directly. Full and effective use of health resources to meet increasing health needs of the population in order to improve the health of the residents should be of concern to the government. A large part of the expenditure on health expenditure is borne by the government, so government consumption can affect health.

Chapter 5 Results

5.1 Descriptive Statistics

Table 4 presents descriptive statistics for the variables that are analyzed in the study. All the variables are averaged over 20 years. In the growth literature, it is a general practice to present averaged data to capture longer effects of different variables (Caselli, Esquivel, & Lefort, 1996; Islam, 1995; Levine, Loayza, & Beck, 2000). The existence of panel data in this study allows us to process a long series of data, which is expected to provide more reliable evidence for the long-term relationship between health and economic development.

Table 4 Descriptive statistics

Variable		Expected sign	Obs	Mean	Std.Dev.
Life expectancy at birth	years (total)		4795	69.20606	9.501416
Infant mortality	per 1000 live births (total)		4632	31.77951	29.5006
Under-5 mortality	per 1000 live births		4632	45.02029	48.18382
Female survival to 65	% of cohort		4656	75.63688	15.49508
Male survival to 65	% of cohort		4656	66.22527	15.6455
Log of GDP per capita	current US$	+	4834	8.342627	1.626156
Gini index	World Bank estimates	-	1443	38.29279	9.017977
Population growth	annual %	-	5172	1.424623	1.526062
Population density	people per sq.km of land area	+	5135	396.4232	1836.947
Ratio of female		-	4649	50.06667	2.835962
Hospital beds	per 1000 people	+	2016	4.080877	2.884775
Nurse and midwives	per 1000 people	+	1636	4.376017	4.053224
Log of CO_2 emissions	metric tons per capita	-	4020	0.621081	1.644607
School enrollment	primary (% gross)	+	3761	101.8678	15.54572
Log of general government final consumption	current US$	+	4001	22.19265	2.259957

5.2. Justification of Fixed-Effects Modeling

Breusch and Pagan Lagrangian Multiplier test results show that the null hypothesis of heteroskedasticity is rejected (p<0.01) and heteroskedasticity assumed. And the F-test also show that it's statistically significant (p<0.01). So fixed-effects model is better than pooled OLS. And last, we can see from the test results that almost all the Hausman test results are statistically significant (p<0.01). It means that fixed effect model is better than random effect model. So this study uses fixed effect model to analyze the preliminary results.

Table 5 Fixed-effects model justification: Life expectancy at birth

Model	1	2	3	4
Breusch and Pagan Lagrangian Multiplier test	2579.69***	2395.10***	266.14***	308.50***
Hausman test	60.22***	85.09***	27.69***	50.07***
F-test for fixed effects	66.55***	62.43***	61.65***	70.82***
Number of observations	1441	1401	420	389

Notes: ***1% levels of significance; **5% levels of significance; *10% levels of significance.

Table 6 Fixed-effects model justification: Infant mortality

Model	1	2	3	4
Breusch and Pagan Lagrangian Multiplier test	2638.00***	1600.47***	187.16***	263.20***
Hausman test	24.95***	76.03***	6.52	11.61
F-test for fixed effects	48.17***	39.15***	68.29***	80.40***
Number of observations	1430	1401	420	389

Notes: ***1% levels of significance; **5% levels of significance; *10% levels of significance.

Table 7 Fixed-effects model justification: Under-5 mortality

Model	1	2	3	4
Breusch and Pagan Lagrangian Multiplier test	2168.48***	1353.25***	132.65***	190.11***
Hausman test	26.28***	66.27***	-16.21	33.86***
F-test for fixed effects	42.88***	34.51***	83.20***	90.91***
Number of observations	1430	1401	420	389

Notes: ***1% levels of significance; **5% levels of significance; *10% levels of significance.

Table 8 Fixed-effects model justification: Female survival to age 65

Model	1	2	3	4
Breusch and Pagan Lagrangian Multiplier test	2218.94***	1854.59***	140.40***	193.47***
Hausman test	99.38***	166.13***	26.26***	18.86**
F-test for fixed effects	83.70***	74.66***	155.22***	145.98***
Number of observations	1429	1401	420	389

Notes: ***1% levels of significance; **5% levels of significance; *10% levels of significance.

Table 9 Fixed-effects model justification: Male survival to age 65

Model	1	2	3	4
Breusch and Pagan Lagrangian Multiplier test	4848.02***	3093.81***	291.52***	261.02
Hausman test	35.88***	36.77***	-6.69	36.17***
F-test for fixed effects	87.87***	68.09***	54.09***	56.69***
Number of observations	1429	1401	420	389

Notes: ***1% levels of significance; **5% levels of significance; *10% levels of significance.

5.3 Regression Results

5.3.1 Fixed effects (FE) regressions

This study identifies four different models through which health is affected by economic development. The models, i.e. regression specifications, are shown in the diagram below. GDP per capita and Gini index are the explanatory variables in Model 1. Model 2 includes additionally population characteristics, including population growth, population density and percentage of female population. Model 3 includes additionally health-related supply, namely the number of hospital beds and that of nurses and midwives. Finally, Model 4 is the full model and includes all explanatory variables: which are GDP per capita, Gini index, population growth, population density, percentage of female population, hospital beds, nurses and midwives, CO_2 emissions, school enrollment and general government final consumption. Tables A.1 ~ A.4 show the FE results of each of the 5 dependent variables. (Appendix)

Table 10 Fixed-effects results, not accounting for potential endogeneity

Variables	Model 1	Model 2	Model 3	Model 4
Panel A: Life expectancy at birth				

Log of GDP per capita	3.300***	3.121***	2.354***	2.712***
	(0.226)	(0.218)	(0.183)	(0.665)
Gini index	-0.053*	-0.049	-0.042	-0.039
	(0.031)	(0.031)	(0.026)	(0.025)
Panel B: Infant mortality				
Log of GDP per capita	-10.418***	-9.752***	-7.071***	-2.352
	(0.937)	(0.956)	(0.957)	(1.728)
Gini index	0.252*	0.231*	0.111	0.015
	(0.143)	(0.139)	(0.133)	(0.103)
Panel C: Under-5 mortality				
Log of GDP per capita	-14.929***	-13.732***	-9.004***	-2.437
	(1.609)	(1.595)	(1.247)	(2.270)
Gini index	0.376	0.338	0.095	-0.025
	(0.259)	(0.256)	(0.168)	(0.134)
Panel D: Female survival to age 65				
Log of GDP per capita	4.503***	4.169***	2.869***	2.394***
	(0.345)	(0.332)	(0.283)	(0.888)
Gini index	-0.079	-0.062	-0.104**	-0.091*
	(0.048)	(0.048)	(0.044)	(0.047)
Panel E: Male survival to age 65				
Log of GDP per capita	5.429***	5.204***	4.157***	5.767***
	(0.407)	(0.420)	(0.379)	(1.512)
Gini index	-0.088*	-0.084*	-0.185***	-0.191**
	(0.047)	(0.048)	(0.067)	(0.077)
Demographic Factors	No	Yes	Yes	Yes
Medical Factors	No	No	Yes	Yes
Other controls	No	No	No	Yes

Notes: ***1% levels of significance; **5% levels of significance; *10% levels of significance.

The results demonstrate that in general log of GDP per capita enter the regression positively and are statistically significant ($p<0.01$), except for Model 4 for infant mortality and under-5 mortality. The effects of Gini index on different health indicators are less consistent. It is statistically significant ($p<0.1$) when life expectancy is the dependent variable only in Model 1. When infant mortality is the dependent variable, Gini index is significant ($p<0.1$) in Models 1 and 2. However, it is statistically insignificant for under-5 mortality but statistically significant for male survival to age 65. With regard to female survival to age 65, it is significant only in Models 3 and 4.

This study shows different specifications for health regressions (Models 1-4). It should be noted that this study considers Model 4 to be the preferred choice, not only because it generally has higher R2 values, but also because the other models may have the problem of omitted variable bias, leaving out theoretically important variables.

Impacts of the other control variables are shown in the appendix. Population growth has a negative impact on life expectancy ($p<0.01$) and a positive impact on infant mortality ($p<0.1$) and under-5 mortality ($p<0.1$). This is consistent with the previous literature. However, the increasing ratio of the female population decreases infant mortality ($p<0.05$) and under-5 mortality ($p<0.05$). This may be because women spend more time with their babies, which can reduce infant mortality to some extent, and educated women can change unhealthy behaviors and promote infant and young child health. Similarly, school enrollment ($p<0.05$) decreases under-5 mortality. Also it can be observed that CO_2 emissions have significant negative effects on life expectancy ($p<0.01$), infant mortality ($p<0.01$) and male survival to age 65 ($p<0.01$). However, the impact of CO_2 emissions on mortality and under-5 mortality is different from the expected result, possibly because of the low CO_2 emissions of underdeveloped economies and the large differences with those in developed countries. In 2006, for example, Chinese emissions were 4.74 tons, compared with 19.37 and 9.78 tons in the United States and Japan (China Climate Change Information Network). Hospital beds was negatively correlated with life expectancy. This result seems to contradict the traditional view that there is a positive correlation between health resources and health. The number of nurses and midwives ($p<0.01$) is negatively correlated with under-5 mortality. General government final consumption has a positive effect on health which is consistent with expected sign. Government can improve health by increasing investment in health.

5.3.2 FE-2SLS Regressions

The results above in general demonstrate a significant impact of economic development on health. However, endogeneity may exist due to potential reverse causality between economic development and health. Therefore, this study uses FE and 2SLS to regress the full model, respectively. And then uses Hausman test to test whether the endogenous problem exists. The results show that the null hypothesis should be rejected, that is, there is an endogenous problem.

To address the endogeneity problem, Model 4 is estimated using the fixed-effects two-stage-least-squares (FE-2SLS) method, where log of GDP per capita and Gini index are considered endogenous. On the use of instrumental variables, Sharma (2018) and Granados & Ionides (2008) both take lag variables as instrumental variables. So in this study, the instrumental variables (IVs) are 2-year lagged GDP per capita (in log terms) and Gini index. Two-year lagged log GDP per capita ($p<0.01$) and two-year lagged Gini index ($p<0.01$) have proved to be positively correlated with the current-year log GDP per capita and the current-year Gini index, providing evidence for the persistence of GDP per capita and Gini index and the fact that they represent reasonably good IVs.

The estimation results are shown in Table 11. It can be seen that the impact of log GDP per capita is persistent. When log GDP per capita is regarded as an exogenous factor, its effect on most of the health outcomes is significant, except for infant mortality and under-5mortality. However, when log GDP per capita is properly endogenized, it now has a positive and statistically significant effect on all health variables, suggesting that endogeneity bias exists in the simple FE regressions. On the other hand, Gini index, which, in the FE analysis, is significant for survival to age 65, is insignificant throughout in the FE-2SLS analysis.

The coefficients of the other variables also change. For life expectancy and female survival to age 65, government final consumption becomes significant in the FE-2SLS analysis. The number of hospital beds and the number of nurses and midwives become statistically significant for the regressions of survival to age 65, although the signs are not as expected. The other explanatory variables have the expected signs but their statistical significance is inconsistent, suggesting that mechanisms through which the explanatory influence different health outcomes are different.

Table 11 FE-2SLS results

Variables	Life expectancy		Infant mortality		Under-5 mortality		Female survival to 65		Male survival to 65	
	FE	2SLS	FE	2SLS	FE	2SLS	FE	2SLS	FE	2SLS
Log of GDP per capita	2.712***	1.915***	-2.352	-3.189***	-2.437	-3.706***	2.394***	2.166***	5.767***	4.336***
	(0.665)	(0.304)	(1.728)	(0.676)	(2.270)	(0.799)	(0.888)	(0.319)	(1.512)	(0.679)
Gini index	-0.039	-0.040	0.015	0.103	-0.025	0.111	-0.091*	-0.058	-0.191**	-0.096
	(0.025)	(0.031)	(0.103)	(0.112)	(0.134)	(0.140)	(0.047)	(0.040)	(0.077)	(0.074)
Population growth	-0.316***	-0.246***	0.606*	0.597**	0.823*	0.814**	-0.042	0.042	-0.188	0.105
	(0.102)	(0.079)	(0.355)	(0.265)	(0.459)	(0.348)	(0.147)	(0.120)	(0.220)	(0.208)

Population density	0.011	0.012	-0.018	-0.035	-0.031	-0.054	0.0001	0.001	-0.019	-0.019
	(0.002)	(0.008)	(0.031)	(0.030)	(0.044)	(0.044)	(0.010)	(0.009)	(0.016)	(0.017)
Ratio of Female	0.024	-0.053	-2.740**	-1.969**	-3.829**	-2.658**	0.605	0.516	-1.040	-0.303
	(0.454)	(0.447)	(1.115)	(0.816)	(1.530)	(1.078)	(0.523)	(0.390)	(0.371)	(0.814)
Hospital beds	-0.187*	-0.314***	-0.216	-0.230	-0.322	-0.309	-0.107	-0.238**	-0.382	-0.855***
	(0.111)	(0.094)	(0.280)	(0.280)	(0.368)	(0.371)	(0.123)	(0.103)	(0.292)	(0.255)
Nurses and midwives	0.031	-0.016	-0.052	0.027	-0.049	0.032	0.019	-0.041**	0.021	-0.100***
	(0.023)	(0.024)	(0.035)	(0.033)	(0.043)	(0.040)	(0.019)	(0.019)	(0.037)	(0.036)
Log of CO_2 emissions	-2.289***	-1.248***	-4.753***	-4.376***	-6.266***	-5.510***	-0.280	0.143	-3.959***	-1.976**
	(0.448)	(0.417)	(1.285)	(1.267)	(1.712)	(1.588)	(0.608)	(0.510)	(1.017)	(0.863)
School enrollment	-0.009	-0.020	-0.031	-0.014	-0.058	-0.020	0.014	0.001	0.004	0.010
	(0.013)	(0.014)	(0.053)	(0.049)	(0.073)	(0.064)	(0.020)	(0.017)	(0.032)	(0.029)
Log of government consumption	0.384	0.737**	-3.711**	-2.414***	-5.247**	-3.198***	0.653	0.700**	-0.290	0.644
	(0.620)	(0.280)	(1.710)	(0.715)	(2.279)	(0.872)	(0.783)	(0.297）	(1.355)	(0.515)
Constant	45.198**	48.486**	274.586***	208.372***	378.440***	274.189***	20.336	26.121	97.679**	46.680
	(24.026)	(23.568)	(71.133)	(44.552)	(100.220)	(60.597)	(30.153)	(20.691）	(47.625)	(42.911)
Observations	389	353	389	353	389	353	389	353	389	353
R2	0.5347	0.5133	0.5167	0.5294	0.4491	0.4428	0.5649	0.5553	0.3550	0.3485

Notes: ***1% levels of significance; **5% levels of significance; *10% levels of significance.

5.3.3 Sub-sample Analyses

The preferred FE-2SLS is replicated in sub-samples of rich and poor countries, which are separated using the World Bank's country classification in the last year of the data.

1) High-income countries

The estimation results are shown in Table 12. For high-income countries, it can be seen that the impact of log GDP per capita is persistent. GDP per capita, as endogenous and exogenous variables, has a positive and statistically significant effect on all health variables. When Gini index is regarded as an exogenous factor, its effect on female survival to age 65 is significant. However, when Gini index is endogenized, it has no relationship with health, suggesting that endogeneity bias exists in the simple FE regressions.

The coefficients of the other variables also change. Population growth becomes statistically insignificant on survival to age 65 for female and male population in the FE-2SLS analysis. Population growth leads to an increase in the labor force and human capital, especially health-related human capital, which promotes health. The results also show that an increase in the female population will decrease infant mortality ($p<0.1$) and under-5 mortality ($p<0.05$). For life expectancy, infant mortality and under-5 mortality, government final consumption becomes significant in the FE-2SLS analysis. The number of hospital beds and the number of nurses and midwives become statistically significant for the regressions of life expectancy and survival to age 65, although the signs are not as expected.

2) Low-income countries

Table 13 shows regression results for low-income countries. GDP per capita has a positive and statistically significant impact on life expectancy and male survival to age 65. When both log GDP and Gini index are regarded as endogenous factors, their effects on health are different with as exogenous factors, suggesting that endogeneity bias exists in the simple FE regressions. Gini index is statistically significant for infant mortality, under-5 mortality and female survival to age 65.

Regarding the other variables, the results also change. Population growth becomes statistically significant only for survival to age 65 for the female and the male population in the FE-2SLS analysis. The ratio of the female population becomes statistically significant for all of health outcomes. The number of nurses and midwives become statistically insignificant for all dependent variables. Government final consumption becomes significant on life expectancy and male survival to age 65 but log CO_2 emissions become statistically insignificant in the FE-2SLS analysis. The sign of the number of hospital beds also is not as expected.

By comparing high-income countries with low-income countries, it can be seen that the effect of GDP per capita on the health of high-income countries is more obvious; it is statistically significant in all health outcomes. However, Gini index has a great influence on health in low-income countries, consistent with the fact that income (and, correspondingly, health) inequality is prevalent in low-income countries. The impact of population growth on health is significantly different in the two groups of countries. For life expectancy, infant mortality and under-5 mortality for high-income countries, it has a negative impact, while for survival to age 65 for low-income countries, it has a positive effect. Moreover, in high-income countries, the ratio of the female population is associated with infant and under-5 mortality, and in low-income countries, it has a significant impact on overall health. CO_2 emissions is statistically significant in high-income countries, but not in low-income countries. With respect to the other explanatory variables, there seem to be no significant differences between the two groups of countries.

Table 12 FE-2SLS regression results of high-income countries

Variables	Life expectancy		Infant mortality		Under-5 mortality		Female survival to 65		Male survival to 65	
	FE	2SLS	FE	2SLS	FE	2SLS	FE	2SLS	FE	2SLS
Log of GDP per capita	3.091***	2.146***	-4.240***	-3.753***	-5.346***	-4.438***	3.261***	2.411***	6.781***	4.720***
	(0.676)	(0.346)	(1.355)	(0.667)	(1.569)	(0.766)	(0.813)	(0.366)	(1.555)	(0.796)
Gini index	-0.034	-0.025	-0.027	0.002	-0.067	-0.030	-0.075	-0.013	-0.161*	-0.043
	(0.028)	(0.035)	(0.111)	(0.121)	(0.148)	(0.149)	(0.049)	(0.039)	(0.082)	(0.082)
Population growth	-0.411***	-0.313***	0.849***	0.636**	1.103***	0.800**	-0.213*	-0.061	-0.403**	-0.085
	(0.094)	(0.071)	(0.299)	(0.241)	(0.381)	(0.307)	(0.111)	(0.097)	(0.180)	(0.178)
Population density	0.020**	0.021***	-0.021	-0.023	-0.029	-0.030	0.010	0.009	-0.004	-0.002
	(0.009)	(0.007)	(0.017)	(0.014)	(0.021)	(0.018)	(0.010)	(0.007)	(0.019)	(0.015)
Ratio of female	-0.134	-0.166	-1.138	-1.065*	-1.498*	-1.414**	0.080	0.212	-1.380	-0.720
	(0.458)	(0.477)	(0.710)	(0.579)	(0.880)	(0.701)	(0.450)	(0.375)	(0.856)	(0.820)
Hospital beds	-0.122	-0.282***	-0.363	-0.321	-0.475	-0.404	-0.018	-0.189**	-0.283	-0.800***
	(0.112)	(0.100)	(0.244)	(0.268)	(0.322)	(0.351)	(0.107)	(0.098)	(0.288)	(0.261)
Nurses and midwives	0.036	-0.023	-0.067*	-0.023	-0.073*	0.026	0.026	-0.042**	0.033	-0.108***
	(0.023)	(0.024)	(0.035)	(0.035)	(0.042)	(0.043)	(0.019)	(0.019)	(0.037)	(0.037)
Log of CO_2 emissions	-2.299***	-1.254***	-4.612***	-4.742***	-5.794***	-5.860***	-0.380	0.229	-3.655***	-1.817**
	(0.488)	(0.415)	(1.255)	(1.143)	(1.668)	(1.445)	(0.546)	(0.407)	(1.000)	(0.691)
School enrollment	-0.001	-0.019	0.014	0.003	0.016	0.005	0.004	-0.005	0.014	0.000
	(0.015)	(0.014)	(0.037)	(0.039)	(0.044)	(0.045)	(0.021)	(0.014)	(0.039)	(0.029)
Log of general government final	0.097	0.618**	-1.868	-1.994***	-2.275	-2.623***	-0.173	0.491	-1.126	0.366

consumption										
	(0.640)	(0.292)	(1.549)	(0.671)	(1.853)	(0.799)	(0.748)	(0.320)	(1.435)	(0.568)
Constant	54.596**	53.660**	164.365***	158.818***	209.617***	203.774***	58.064**	42.948**	121.184**	68.800
	(25.182)	(25.574)	(49.905)	(31.466)	(62.401)	(38.710)	(27.375)	(20.635)	(52.477)	(43.785)
Number of observations	334	302	334	302	334	302	334	302	334	302
R2	0.4368	0.4247	0.4890	0.4805	0.4307	0.4721	0.5179	0.6024	0.5827	0.7467

Notes: ***1% levels of significance; **5% levels of significance; *10% levels of significance.

Table 13 FE-2SLS regression results of low-income countries

Variables	Life expectancy		Infant mortality		Under-5 mortality		Female survival to 65		Male survival to 65	
	FE	2SLS	FE	2SLS	FE	2SLS	FE	2SLS	FE	2SLS
Log of GDP per capita	-0.226	0.758***	2.946	0.834	6.741**	1.215	-2.176***	0.402	-1.776	1.671**
	(0.478)	(0.198)	(1.817)	(1.771)	(2.958)	(2.386)	(0.702)	(0.514)	(1.803)	(0.708)
Gini index	-0.022	-0.074	-0.167	0.524**	-0.336*	0.759**	-0.010	-0.119*	-0.144	-0.097
	(0.038)	(0.050)	(0.107)	(0.223)	(0.185)	(0.340)	(0.038)	(0.061)	(0.109)	(0.099)
Population growth	0.949***	0.420	-0.535	-0.117	1.196	1.065	2.286***	2.034***	5.883***	4.078***
	(0.330)	(0.384)	(1.929)	(2.522)	(3.189)	(3.634)	(0.315)	(0.634)	(1.511)	(1.098)
Population density	-0.009	0.003	-0.053	-0.148*	-0.020	-0.216*	-0.024	0.016	0.000	0.005
	(0.009)	(0.013)	(0.063)	(0.076)	(0.097)	(0.110)	(0.019)	(0.024)	(0.028)	(0.046)
Ratio of female	2.163**	2.740*	-19.723**	-14.240*	-26.642**	-18.369*	5.241**	5.659*	1.782	7.406*
	(0.951)	(1.333)	(7.925)	(6.872)	(11.338)	(9.593)	(2.483)	(2.822)	(2.261)	(4.021)
Hospital beds	0.003	-0.101	2.313	1.941*	3.127	2.465*	-0.426*	-0.571	0.516	-0.437
	(0.222)	(0.185)	(1.559)	(0.995)	(2.287)	(1.251)	(0.217)	(0.414)	(0.572)	(0.702)
Nurses and midwives	-0.086	-0.007	-0.518	0.540	-0.590	0.875	-0.037	0.093	-0.062	0.243
	(0.183)	(0.070)	(1.242)	(0.579)	(1.703)	(0.817)	(0.406)	(0.137)	(0.377)	(0.333)
Log of CO_2 emissions	-1.405*	-0.480	-1.585	-3.390	-1.295	-4.939	-1.354	-0.341	-6.072*	-2.852
	(0.779)	(0.768)	(3.003)	(2.818)	(4.611)	(3.930)	(0.966)	(1.232)	(3.223)	(3.262)
School enrollment	-0.021	-0.014	0.020	-0.093	0.006	-0.139	-0.008	-0.007	-0.049	-0.002
	(0.031)	(0.026)	(0.119)	(0.143)	(0.190)	(0.212)	(0.034)	(0.037)	(0.076)	(0.065)
Log of general government final consumption	2.584***	1.115**	-9.477***	-2.582	-16.868***	-2.994	5.218***	1.497*	5.688***	1.771
	(0.247)	(0.453)	(1.389)	(1.572)	(2.452)	(2.243)	(0.428)	(0.757)	(0.806)	(2.011)

Constant	-91.758**	-96.528	1219.466***	804.280**	1709.936***	1029.026**	-283.478	-244.116	-136.426	-364.557*
	(47.549)	(68.990)	(396.393)	(350.341)	(564.282)	(488.983)	(123.552)	(143.944)	(110.950)	(209.686)
Number of observations	55	51	55	51	55	51	55	51	55	51
R2	0.0001	0.0247	0.1820	0.2172	0.1553	0.1591	0.0140	0.0229	0.0007	0.1311

Notes: ***1% levels of significance; **5% levels of significance; *10% levels of significance.

Chapter 6 Discussion

This paper investigates whether economic development has a causal effect on health, using panel of 217 economies for the period 1995–2018. It uses life expectancy at birth, infant mortality, under-5 mortality, male and female survival to age 65 as proxies for population health. It uses a fixed effects estimation method and solves for endogeneity using a two-stage least squares (2SLS) approach. Through different model specifications and econometric procedures, GDP per capita is found to have a consistently positive and statistically significant effect on health. Evidence for the impact of Gini index on health is weak. There are also other factors that contribute to aggregate-level health. Population growth and the ratio of the female population have an impact on life expectancy, infant mortality and under-5 mortality. The results also demonstrate health consequences of climate change; CO_2 emissions has a generally negative effect on most health outcomes in this study.

The fact that GDP per capita has a positive impact on health is consistent with previous studies. (Amartya Sen, 2001) concluded that the rate of decline of mortality in England and Wales has historically been inversely correlated with economic growth, and that decades of strong growth have been related to decline in life expectancy. The results of this study also show that the relationship between inequality and health, albeit weak in general, is stronger in low-income countries, compared to high-income countries. This is consistent with (Karlsson et al., 2010). CO_2 emission has a negative impact on life expectancy and survival to age 65 in high-income countries, consistent with (Drabo, 2011). This supports the view that environmental quality is an important channel through which income inequality affects population health. These results apply to air pollution indicators (CO_2 and SO_2) and water-pollution indicators (BOD). For rich and poor countries, this finding is also powerful.

This study shows that, while the effect of GDP on health is evident, policymakers should not focus solely on GDP as a potential booster of population health, as other factors remain important. More specifically, income inequality negatively impacts health, especially in low-income countries. It is important for countries with high income inequalities to consider implementing redistributive policies not only to improve the quality of life of the population in general but also to circumvent their negative impact on health. Attention should also be paid to health of the female population. This study shows that an increase in the ratio of the female population can improve health overall and this is especially true of infant and under-5 mortality, which is unsurprising given that children's health is determined importantly by maternal inputs. In addition, environmental issues remain a matter of high concern, especially in high-income countries, where CO_2 emissions have a negative impact on health. It is important for policymakers to strike the right balance between the environment and economic development.

This paper has some limitations. First, some developing economies do not have access to comprehensive macroeconomic data for 1995-2018, which mean the data used in this study may be completely globally representative. Second, the choice of instrumental variables (IVs) in the data is limited. Although many studies in the literature have similarly used lag values of endogenous variables as IVs, the IVs used here may not be sufficiently credible as they can also be considered endogenous in a dynamic setting. Third, while we use several health variables, including life expectancy at birth; infant mortality; under-5 mortality; female survival to age 65 and male survival to age 65 to capture the multi-dimensionality of health, they still might not be enough. For example, the life expectancy of a country may be high, but most of its population may suffer from disease and may not be productive. A better measure may be Health Adjusted Life Expectancy (HALE), which can calculate the healthy years of life that from a child born. However, data related to HALE or other population health indicators, such as adult mortality (AMR) or child mortality (U5MR), are only available in a relatively short period of time.

Nevertheless, this study makes several contributions. In view of these circumstances where data are imperfect, the study uses these five variables as proxy for health, avoiding the deviation caused by a single factor and can obtain long-term data. In addition, the use of panel data is an important feature of this study, leading to more robust evidence. Moreover, the effects of economic development on health can be seen through comparisons of countries with different income levels, so that the impacts of high-income and low-income countries can be compared.

APPENDIX

Table A.1 FE results of life expectancy at birth as dependent variable

Variables	Model 1	Model 2	Model 3	Model 4
Log of GDP per capita	3.300***	3.121***	2.354***	2.712***
	(0.226)	(0.218)	(0.183)	(0.665)
Gini index	-0.053*	-0.048	-0.042	-0.039
	(0.031)	(0.031)	(0.026)	(0.025)
Population growth		-0.266*	-0.416***	-0.316***
		(0.151)	(0.127)	(0.102)
Population density		0.023***	0.022**	0.011
		(0.008)	(0.010)	(0.002)
Ratio of Female		0.186	0.184	0.024
		(0.457)	(0.665)	(0.454)
Hospital beds			-0.443***	-0.187*
			(0.105)	(0.111)
Nurses and midwives			0.071*	0.031
			(0.038)	(0.023)
Log of CO_2 emissions				-2.289***
				(0.448)
School enrollment				-0.009
				(0.013)
Log of general government final consumption				0.384
				(0.620)
Constant	46.065***	35.489	44.559	45.198**
	(2.634)	(23.61)	(33.822)	(24.026)
Number of obs	1441	1401	420	389
R2	0.6819	0.5095	0.4139	0.5347

Notes: ***1% levels of significance; **5% levels of significance; *10% levels of significance.

Table A.2 FE results of infant mortality as dependent variable

Variables	Model 1	Model 2	Model 3	Model 4
Log of GDP per capita	-10.418***	-9.752***	-7.071***	-2.352
	(0.937)	(0.956)	(0.957)	(1.728)
Gini index	0.252*	0.231*	0.111	0.015
	(0.143)	(0.139)	(0.133)	(0.103)
Population growth		0.730	0.689*	0.606*
		(0.806)	(0.394)	(0.355)
Population density		-0.093***	-0.035	-0.018
		(0.030)	(0.035)	(0.031)
Ratio of Female		-2.304	-2.314*	-2.740**
		(1.582)	(1.269)	(1.115)
Hospital beds			-0.519	-0.216
			(0.322)	(0.280)
Nurses and midwives			-0.087	-0.052
			(0.076)	(0.035)
Log of CO_2 emissions				-4.753***
				(1.285)
School enrollment				-0.031
				(0.053)
Log of general government final consumption				-3.711**
				(1.710)
Constant	100.866***	223.408***	198.754***	274.586***
	(11.264)	(83.517)	(66.407)	(71.133)
Number of obs	1430	1401	420	389
R2	0.6108	0.3766	0.5268	0.5167

Notes: ***1% levels of significance; **5% levels of significance; *10% levels of significance.

Table A.3 FE results of under-5 mortality as dependent variable

Variables	Model 1	Model 2	Model 3	Model 4
Log of GDP per capita	-14.929***	-13.732***	-9.004***	-2.437
	(1.609)	(1.595)	(1.247)	(2.270)
Gini index	0.376	0.338	0.095	-0.025
	(0.259)	(0.256)	(0.168)	(0.134)
Population growth		1.402	0.920*	0.823*
		(1.334)	(0.521)	(0.459)
Population density		-0.164***	-0.054	-0.031
		(0.055)	(0.051)	(0.044)
Ratio of Female		-3.724	-3.166*	-3.829**
		(2.906)	(1.666)	(1.530)
Hospital beds			-0.694*	-0.322
			(0.406)	(0.368)
Nurses and midwives			-0.086	-0.049
			(0.090)	(0.043)
Log of CO_2 emissions				-6.266***
				(1.712)
School enrollment				-0.058
				(0.073)
Log of general government final consumption				-5.247**
				(2.279)
Constant	142.025***	340.562**	266.500***	378.440***
	(20.030)	(153.658)	(88.610)	(100.220)
Number of obs	1430	1401	420	389
R2	0.5340	0.2825	0.4415	0.4491

Notes: ***1% levels of significance; **5% levels of significance; *10% levels of significance.

Table A.4 FE results of female survival to age 65 as dependent variable

Variables	Model 1	Model 2	Model 3	Model 4
Log of GDP per capita	4.503***	4.169***	2.869***	2.394***
	(0.345)	(0.332)	(0.283)	(0.888)
Gini index	-0.079	-0.062	-0.104**	-0.091*
	(0.048)	(0.048)	(0.044)	(0.047)
Population growth		0.182	-0.095	-0.042
		(0.203)	(0.136)	(0.147)
Population density		0.035***	0.008	0.000
		(0.012)	(0.011)	(0.010)
Ratio of Female		0.387	0.532	0.605
		(0.619)	(0.510)	(0.523)
Hospital beds			-0.207*	-0.107
			(0.111)	(0.123)
Nurses and midwives			0.041	0.019
			(0.027)	(0.019)
Log of CO_2 emissions				-0.280
				(0.608)
School enrollment				0.014
				(0.020)
Log of general government final consumption				0.653
				(0.783)
Constant	45.508***	24.044	35.613	20.336
	(4.178)	(32.493)	(25.823)	(30.153)
Number of obs	1429	1401	420	389
R2	0.6008	0.4115	0.5691	0.5649

Notes: ***1% levels of significance; **5% levels of significance; *10% levels of significance.

Table A.5 FE results of male survival to age 65 as dependent variable

Variables	Model 1	Model 2	Model 3	Model 4
Log of GDP per capita	5.429***	5.204***	4.157***	5.767***
	(0.407)	(0.420)	(0.379)	(1.512)
Gini index	-0.088*	-0.084*	-0.185***	-0.191**
	(0.047)	(0.048)	(0.067)	(0.077)
Population growth		-0.097	-0.300	-0.188
		(0.205)	(0.251)	(0.220)
Population density		0.027**	-0.005	-0.019
		(0.013)	(0.020)	(0.016)
Ratio of Female		0.083	-0.797	-1.040
		(0.680)	(1.132)	(0.371)
Hospital beds			-0.887***	-0.382
			(0.251)	(0.292)
Nurses and midwives			0.064	0.021
			(0.050)	(0.037)
Log of CO_2 emissions				-3.959***
				(1.017)
School enrollment				0.004
				(0.032)
Log of general government final consumption				-0.290
				(1.355)
Constant	26.877***	21.481	87.769	97.679**
	(4.516)	(35.236)	(57.668)	(47.625)
Number of obs	1429	1401	420	389
R2	0.5876	0.5422	0.6283	0.3550

Notes: ***1% levels of significance; **5% levels of significance; *10% levels of significance.

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