International Journal of Innovation, Creativity and Change. www.ijicc.net
Volume 14, Issue 11, 2020

Human Health and Worker Productivity: Evidence from Middle-Income Countries

Hafiz Muhammad Abubakar Siddique[a], Ghulam Mohey-ud-din[b], Adiqa K. Kiani[c], [a] Federal Urdu University of Arts, Science & Technology Islamabad, Pakistan and GIFT University, Gujranwala, Pakistan, [b]The Urban Unit, Lahore, Punjab, Pakistan, [c]Federal Urdu University of Arts, Science & Technology Islamabad, Pakistan, Email: [a]bakar343@gmail.com, [b]dr.moheyuddin@urbanunit.gov.pk, [c]adiqakian@gmail.com

This study strives to scrutinise the influence of various indicators of health status on labour productivity. It is primarily the worker's health condition which determines the economic growth rate of a country. The study investigates to what extent these indicators of health influence output per person for 75 middle-income countries (MIC) for 1991-2016. The empirical results exhibit improved health status is associated with increased productivity. Results also reveal that physical capital and education has a positive impact on productivity, whereas participation in the labour force has a negative impact on output per person. An important finding of this study is that the impact of health on productivity is considerably greater in upper-middle-income countries (UMIC) in comparison to lower-middle-income countries (LMIC). The main findings of the study are robust to other determinants of productivity. This study suggests that policy makers should focus on improving the health in MIC.

Key words: *Productivity, Life expectancy, Undernourishment, Panel data.*

1. Introduction

Existing theories on growth stress that a country needs capital accumulation and technological advancement for economic growth. Besides physical capital, human capital is considered as most important in determining the economic growth of a country. Individuals can provide and accumulate capital if they are healthy both physically and mentally. Health might stimulate economic development as it is an important type of human capital, therefore, recently researchers are paying considerable attention in determining the role of health as human capital in shaping economic growth. Improved health status changes decisions regarding saving and spending, resulting in increased saving and investment, which in turns boost growth. Moreover, health can affect the rate of growth through education. Children in good health have a high rate of school attendance, enhancing the quality of the labour force, leading to increased output.

Poor health could hinder economic growth and development in most of the developing countries (Schultz, 2005). In these countries, with inadequate provision of social security and health care, welfare losses due to ill-health and ailment can be significant. Individuals, who are suffering from poor health, may not be able to work and support other dependents. At the aggregate level, high disease burden and poor health have an unfavorable influence on a country's productivity level and economic development. According to Bloom et al. (2004) improved health is associated with a 4% increase in the level of output. Enhanced health influences economic development through several ways like human capital investment, fertility, labour supply and productivity etc.

Health can determine the worker's productivity by influencing their physical and mental capabilities. Individuals with poor health do not have enough capacity and potential to do work proficiently, so the rate of economic growth may decline. A fatal disease lowers the quantity of labour supplied, whereas non-fatal and infectious diseases like, malaria, malnutrition and water-borne diseases have severe effects on labour productivity.

Further, poor health adversely influences the accumulation of human capital because of high absenteeism. According to a report of world bank (1993), improvement in health boost economic growth by (1) decreasing losses in production due to a worker's ill health (2) allowing the utilisation of natural resources that were not accessible due to illness (3) increasing school enrollment that makes them able to study and learn better and (4) freely available resources being spent on treating diseases.

Improved health increases productivity through the following ways: (1) by reducing the number of off days due to illness; (2) due to more physical and mental energy; (3) by expanding the time for specialisation and reducing the probability of job disturbance due to diseases and sickness. According to Grossman (1972), an increase in an individual's level of health increases its productivity in activities.

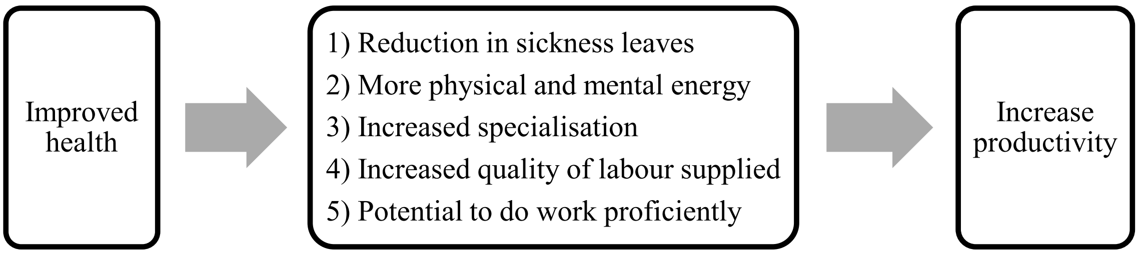

Figure 1: Relationship between health and productivity

The effects of health on economic growth is estimated in the literature (Barro, 1991; Levine and Renelt, 1992; Bhargava et al., 2001; Bloom et al., 2004; Weil, 2007). These studies are different in terms of sample size, variables, data, and estimation method. However, all studies yield more or less the same results: that health has a progressive influence on growth. We argue that health does not influence economic growth directly, but it affects via productivity. Hence, observing the direct influence of health on the growth of an economy may give inaccurate results. So this research adds to the existing literature by scrutinising the association between health and productivity.

The core objective of the research is to explore the influence of human health on worker effectiveness and productivity in MIC. Minute attention had been paid on finding the effect of health on productivity, particularly in developing states. Our study differs from the existing literature in several ways. Firstly, most studies have used life expectancy as a proxy of health; we are going to use two different indicators of health, namely life expectancy and undernourishment. Secondly, this study intends to use panel data to directly estimate the nexus between health and worker productivity. Lastly, mainly the studies are concentrated on developed countries whereas we are carrying analysis for MIC.

The study is organised in the following way: Section 2 covers the existing literature on health-labour productivity. Section 3 demonstrates the framework and model. Section 4 presents the econometric methodology. Section 5 includes an explanation of variables used, data source, descriptive and statistics of the data. Section 6 presents, interpretation and discussion of the results. The last section 7 provides the conclusion of the study followed, limitations and policy recommendation.

2. Literature Review

A worker's contribution to the national output depends upon health status. Workers in good health are more competent and productive as compared to the poor.

Ram and Schultz (1979) asserted that improved health status increases hours of labour supplied by reducing sickness and extending life span. With increased life span, this encourages investment in human capital (mainly via education, increased health expenditures and nutritional status) since returns are expected to accumulate in the future.

Bloom et al. (2000) hold the view that healthy individuals may be less absent from work, are more energetic intellectually and physically, have more incentive to invest in education due to higher life expectancy, and are encouraged to save for retirement leading to greater capital accumulation. It improves survival rate and reduces fertility rate, leading to greater participation in the labour force. Arora (2001) in his study of human health, productivity and economic growth, concluded that improvement in health status raises the working capability of the workforce and causes economic growth to increase by 30-40 percent**.** Tampa (2002) holds the view that health influence productivity by affecting the capacity to work and hours worked. According to the author, health determines productivity by three ways: (1) expectation to live a long life induces individuals to invest in education, since they will benefit from higher returns, (2) the saving will increase, resulting in a greater accumulation of capital and (3) improvement in health increases participation in labour force by decreasing fertility.

By using labour force participation (as an indicator of productivity) and self-rate health, Bound (1991) found that poor health status influences participation of not only sick persons but also of other members of a household. By extending the Solow and Swan neoclassical model and using data for 77 countries, Knowles and Owen (1997) estimated the effect of health (proxied by life expectancy) and education on output per worker. Results of non-linear least square illustrate the positive and significant association between health and output per person, while the effect of education is statistically insignificant. According to Strauss and Thomas (1998), health has a significant influence on labour and its productivity. Poor health is negatively associated with labour productivity and labour supply. They asserted that healthier people are more productive and efficient, and they do not try to skip work owing to sickness and diseases.

By taking into account data for Great Britain for 1780-1980, Fogel (1997) explored the association between population health (proxied by caloric intake) and productivity. He concluded that the proportion of the population that was undernourished, decreases input of labour. Additionally, a greater consumption of calories among those who were already working, improved labour input by 56%. Overall, improvement in nutrition elevated input of labour by 1.95 times. Harris (1999) conducted a study in Canada and discovered that growth in productivity increases an individual's earning capability and further raises their standard of living via the ability to buy additional services and goods.

By using the generalised least square (GLS) estimation method and data on fertility rate, education, government consumption and life expectancy, Mayer (2001) found that advancement in health care facilities boosts efficiency and growth rate of income. Bhargava et al. (2001) analysed the association among worker productivity (measured by the log of the growth rate of GDP per capita) and health. He found that the growth of GDP per capita increases by 0.5% due to 1 % increases in adult survival rate. Bloom et al. (2002) conducted a panel data analysis over 1960-1995, to find out the role of healthiness on labour productivity and economic growth. Health status is measured by life expectancy and adult survival rate (ASR). Results show that labour productivity increases by 2.8% if there is 1% increase in ASR.

In a study comprising data on 15 states in India during 1970-1995, Gupta and Mitra (2004) scrutinised the relationship between health and economic growth. Results indicate that health improvement increases the worker's ability to earn and productivity, which in turn hastens output level and growth. Bloom et al. (2005) in their study, exposed that workforce productivity increases by 2.8 percent due to 1% increment in adult survival rate. By comparing the effects of the macroeconomic model with effects found utilising calibration based on wage regression, they revealed that macroeconomic results are not different from those obtained from microeconomic.

By utilising various survey indicators of health and adult nutrition, Schultz (2005) studied the influence of individual health on labour productivity and individual wages in low income countries, which in turn retard economic growth. The study discovers that improved health has an encouraging and noteworthy impact on productivity. Also, low income countries do not have sufficient resources for investment in health status. Cole and Neumayer (2006) inspected the adverse role of deprived health on factor productivity using data of 52 developing and developed countries for 1965-1996. They argued that poor health influence output growth through its direct impact on the productivity level. To attain their objective, the author's considered undernourishment, the incidence of malaria and water-borne diseases as indicators of health status. They found that the impact of malaria is greater on productivity in comparison to undernourishment and water-borne diseases.

In a pseudo experiment conducted for six months in Central Java Indonesia, Thomas et al. (2006) find that healthier (not anemic) people are less likely to lose work due to illnesses and sleep, and are more vigorous, more working and have higher earnings. Tallinn (2006) analysed the economic consequences of poor health by using data on fertility rate, working-age mortality and life expectancy for Estonia for 1960-2000. Results obtained from OLS and fixed effect regression revealed that poor health has a negative and significant impact on the economy of Estonia and economic outcomes of individuals. Also, by utilising the Estonian labour force survey, the study confirms that on an individual level, poor health has a negative influence on both labour productivity and labour supply. Ill-health influences labour market outcomes by decreasing labour force participation, working hours and productivity.

By utilising a sample of 77 countries over 1980-2000, Soukiazis and Cravo (2007) investigated the association among human capital, health and growth rate. Results disclosed that improved health is linked with increasing human capital stock and productivity of the worker and shrinks the difference between the poor and the rich countries. Using data for Italy and Denmark over 150 years, Knapp (2007) investigated the impact of net nutrition (measured by height) on labour productivity (measured by wage rate). Results revealed that in the 20th century, nutrition in an individual's first 20 years had a favorable and significant impact on the productivity of labour. Also, nutrition fosters growth of physical capital and fortifies cognitive capability, which boosts productivity level.

Umoru and Yaqub (2013) examined the impact of health on the produce of labour in Nigeria. They found that productivity is significantly influenced by the healthy workforce. Also, they concluded that labour supply and demand depend upon a qualification besides health. In Nigeria, productivity could be enhanced by investing in education and health. Madsen (2016) conducted a study employing data for 21 OECD[1] countries for 1812–2009. He concluded that health influence productivity and growth by influencing human capital, schooling, learning, innovation and ideas production.

Sengupta (2017) examined the influence of health on labour productivity and the market for developing and emerging countries. Results revealed that child malnutrition, mortality rate and morbidity due to diarrhea, tuberculosis and malaria are prime factors which influence the labour market by affecting employment, output per person and participation in the workforce. So these nations must focus on enhancing their health status to attain and sustain long term economic development. Adeshina et al. (2019) studied the effect of health and worker productivity on the growth rate in Nigeria during 1981-2017. The empirical results revealed that both health and productivity tend to encourage growth, but the effect of productivity on growth lack statistical significance. So there is a need to enhance productivity by investing in education for robust growth in Nigeria.

To cover the gap in the literature on the linkage between human health and productivity of labour, this research is conducted to unearth the spanking new corroboration about the influence of health on output per person in MIC.

3. Theoretical Framework and Model

A healthy body and mind are most important in performing activities of daily life and a healthy person can enjoy his/her life without being dependent upon others. A health function shows information about the health status of an economy. A model is formulated to find the empirical nexus between health and worker productivity.

3.1 The Aggregate Production Function

The study follows the Cobb-Douglas production function for simplicity

$$Y = AK^{\alpha}(L)^{\beta} \quad (1)$$

where Y is output, A denotes technology, L is labour and K is capital. The wage w earned by a worker and its marginal product is,

$$w = \frac{dY}{dL} = AK^{\alpha}\beta(L)^{\beta-1} \quad (2)$$

$$w = AK^{\alpha}(L)^{\beta}.\beta(L)^{-1} \quad (3)$$

$$w = Y.\beta(L)^{-1} = Y\beta L^{-1} \quad (4)$$

$$w = \frac{dY}{dL} = \beta\,\frac{Y}{L} \quad (5)$$

[1] Organisation for economic co-operation and development

Taking the logarithm of equation (1), our aggregate production function is

$$\ln Y = \ln A + \alpha \ln K + \beta \ln L \quad (6)$$

$$\ln Y = \alpha_0 + \alpha \ln K + \beta \ln L \quad (7)$$

3.2 Worker Productivity and Health

Various methods are used for deriving productivity across the economies and time, but we follow Bloom et al. (2002). Worker productivity (WP) varies across the countries and within the country in the long run.

$$\Delta(WP) = \lambda\,[(WP)^* - WP] + \varepsilon \quad (8)$$

where ε is an unsystematic shock and λ is the rate of worker's productivity towards a maximum and actual level of productivity. Every economy has a maximum level of productivity $(WP)^*$, and an actual level of productivity (WP).

It assumes that the maximum level of productivity for an economy is influenced by worldwide technology and a country's specific features. It can be expressed by;

$$(WP)^* = WP + \delta X \quad (9)$$

$$(WP)^* - WP = \delta X \quad (9a)$$

$$\omega = \delta X \quad (10)$$

$$\ln \omega = \ln(\delta X) \quad (11)$$

$$\ln \omega = \ln\delta + \ln X \quad (11a)$$

where X shows country-specific variables that change productivity and WP expresses the present worldwide productivity. The variable X includes several indicators but income, health and schooling are common. Here the study uses three indicators income (Y), health (H) and schooling (S) which can be expressed as;

$$X = f\,(Y, H, S) \quad (12)$$

It can be shown in Cobb Douglas form by considering X as output which depends on Y, H and S inputs.

$$X = Y^{\varphi}\, H^{\theta}\, S^{\phi} \quad (13)$$

By substituting equation (13) into (11a), it can be formulated in such a way,

$$\ln \omega = \ln\delta + \ln\,(Y^{\varphi}\, H^{\theta}\, S^{\phi}) \quad (14)$$

$$\ln \omega = \ln\delta + \varphi \ln Y + \theta \ln H + \phi \ln S \quad (15)$$

By substituting the equation (7) into (15), we get

$$\ln\omega = \ln\delta + \varphi(\alpha_0 + \alpha \ln K + \beta \ln L) + \theta \ln H + \phi \ln S \quad (16)$$

$$\ln\omega = \ln\delta + \varphi\alpha_0 + \varphi\alpha \ln K + \varphi\beta \ln L + \theta \ln H + \phi \ln S \quad (17)$$

$$p_{it} = \gamma_0 + \gamma_1 k_{it} + \gamma_2 l_{it} + \gamma_3 h_{it} + \gamma_4 s_{it} \quad (18)$$

Eq.18 is an empirical model for panel data analysis which is derived from aggregate production and productivity models, where, $p_{it} = ln\omega$, γ_0=$ln\delta + \varphi\alpha_0$, $\gamma_1 k_{it} = \varphi\alpha lnK$, $\gamma_2 l_{it} = \varphi\beta lnL$, $\gamma_3 h_{it} = \theta lnH$, and $\gamma_4 s_{it} = \phi lnS$.

To check the productivity of a healthy worker, the study used productivity as a dependent variable and health as an independent factor. We have used two proxy variables for health which are used in literature i.e. prevalence of undernourishment and life expectancy (see, for example, Cole and Neumayer, 2006; and Adedayo and Anthony, 2016). Secondary school enrolment and tertiary school enrolment are used for education which is also used by Shahid et al., (2019). So, after addition proxies of health and education equation (18) can be formulated as;

$$p_{it} = \gamma_0 + \gamma_1 k_{it} + \gamma_2 l_{it} + \gamma_3 le_{it} + \gamma_4 sec_{it} \quad (19.1)$$
$$p_{it} = \zeta_0 + \zeta_1 k_{it} + \zeta_2 l_{it} + \gamma\zeta_3 le_{it} + \zeta_4 ter_{it} \quad (19.2)$$
$$p_{it} = \psi_0 + \psi_1 k_{it} + \psi_2 l_{it} + \psi_3 und_{it} + \psi_4 sec_{it} \quad (19.3)$$
$$p_{it} = \varphi_0 + \varphi_1 k_{it} + \varphi_2 l_{it} + \varphi_3 und_{it} + \varphi_4 ter_{it} \quad (19.4)$$

Equations (19.1-19.4) are empirical models which are derived from aggregate production and productivity models. The term *i* is used for countries and *t* is used for time of 1991-2016. The term *p* is used for worker productivity, *k* is capital, *l* is labour, *sec and ter* are school enrolment, *h* is used for health, *le* is used for life expectancy and *und* is used for the prevalence of undernourishment. The term γ_0 is intercept, $\gamma_{1,}\gamma_{2,}\gamma_3$, and γ_4 are the elasticity of capital, labour, life expectancy and schooling concerning worker productivity respectively. The term ψ_0 is intercept, $\psi_{1,}\psi_{2,}\psi_3$, and ψ_4 are the elasticity of capital, labour, undernourishment and schooling concerning worker productivity, respectively.

4. Methodology

Panel data techniques and methods are utilised to check the role of health on labour productivity. Panel data is data that incorporate both time series and cross-sectional data. Fixed effects approach is used in this study based on the Hausman test.

4.1.Fixed Effects Approach

The fixed effects (FE) method is used to evaluate the effect of factors that change over time. It investigates the relationship between the dependent and independent variable for each cross-sectional unit. The FE estimation method controls the impact of those attributes that do not vary with time and assess the net effect of regressor on regressand. For this purpose, the FE model allows variability of attributes in the intercept. This can be demonstrated by placing subscript *i* on intercept.

$$p_{it} = \gamma_i + \gamma_1 k_{it} + \gamma_2 l_{it} + \gamma_3 le_{it} + \gamma_4 sec_{it} \quad (20.1)$$
$$p_{it} = \zeta_i + \zeta_1 k_{it} + \zeta_2 l_{it} + \zeta_3 le_{it} + \zeta_4 ter_{it} \quad (20.2)$$
$$p_{it} = \psi_i + \psi_1 k_{it} + \psi_2 l_{it} + \psi_3 und_{it} + \psi_4 sec_{it} \quad (20.3)$$
$$p_{it} = \varphi_i + \varphi_1 k_{it} + \varphi_2 l_{it} + \varphi_3 und_{it} + \varphi_4 ter_{it} \quad (20.4)$$

where γ_i , ζ_i , ψ_i, and φ_i demonstrate that cross-sectional-unit's intercept is different due to distinctive characteristic of each country.

4.2. Hausman Test

To corroborate which estimation technique (FE or RE) is appropriate we performed the Hausman test. A Hausman test is employed to test the following hypothesis:

$$H_0 = \text{RE model is suitable}$$
$$H_1 = \text{FE model is suitable}$$

Where acceptance of H_0 implies that the RE model is appropriate.

5. Data

This study aims to inspect the relationship between health status and productivity by using data for 75 countries (33 LMIC and 42 UMIC) for 1991-2016. The data source for all variables is World development indicators (WDI). Summary of indicators is shown in Table 1.

In this study the dependent variable is worker productivity (WP) which is measured by the GDP per worker. WP is the ratio of GDP and total employment in a country which is converted into 2010 constant international dollar (I$) at purchasing power parity (PPP) rates. The purchasing power of $I is the same that is in the US.

Health status is the focused independent variable used in this study. Health is measured by two proxy variables namely life expectancy and undernutrition, which is also used by Mayer (2001), Fogel (1997) and Neumayer (2006).

Increased life expectancy (LE) is associated with greater productivity. Expansion of LE encourages knowledge accumulation, and investment in learning and education, which leads to greater productivity (Weil, 2007; Ngangue & Manfred, 2015 and Adedayo & Anthony, 2016; Siddique and Kiani, 2020). LE represents the expected life of a new baby in years without changing the mortality pattern.

Undernourished individuals (UND) are more likely to be weak and lack energy. They are more prone to infectious and other diseases. Also, nutrient deficiency may impede cognitive and physical development, which in turn influences factor productivity (Strauss & Thomas, 1998;

Cole & Neumayer, 2006). According to the report of FAO[2], UND increases in the contracting economies. UND indicates the part of the population (POP) who is unable to consume sufficient food to attain a minimum level of dietary energy. It is measured in numbers, showing the share of people would not be able to consume the minimum level of energy, for example, the number 5 express that 5% population is below the UND.

There is an adverse liaison between labour force participation and the growth rate of productivity. It may be because new labourers may lack sufficient skills and it takes enough time until these new participants become productive (McGuckin and Van Ark, 2005). Although physical capabilities of older labourers might diminish and they lack cognitive capabilities but have higher social perspicacity and experience level (Skirbekk, 2003). It is the ratio of workers and a total population whose ages are fifty and older.

Physical capital is the tools with which workers work. It includes not only plant, machinery and equipment that a firm uses but also the transportation network, roads, and other infrastructure that contribute to the development of an economy. Both the quantity and quality of physical capital affect productivity. Increased investment in capital, results in higher productivity and growth in per capita GDP (Becker et al., 1990; Choudhry, 2009). Capital comprises the change in fixed assets and inventories which is measured in US$ at constant (2010).

Education plays an important role in determining productivity. Since the 19th century increment in education level is accounted for 1/5th to 1/3rd of economic development in the United States (Barro and Lee 2015). At the individual level, education seeks to build up cognitive skills (constant improvement in skills and knowledge) and non-cognitive skills (Downes, A. S., 2001). The role of education is essential in intensifying the human capital of a nation that results in growth in productivity.

The study uses two proxy variables for education, i.e. secondary school (SEC) and tertiary school (TER) enrollment, which are also used in literature (Siddique et al., 2018; Shahid et al., 2019). SEC is basic schooling which starts with the primary education and it is the ratio of total enrollment and POP of the relevant age set. TER begins after the completion of SEC and it is the ratio of total enrollment and POP of the respective age set.

[2] http://www.fao.org/sdg-progress-report/en/#sdg-2

Table 1: Summary of Variables

Variable	Summary
Worker productivity (WP)	Output per worker measured as GDP per person employed (PPP in dollars at constant 2010)
Health (LE)	Total life expectancy in years at birth
Health (UND)	Prevalence of undernourishment (% of POP[3]), measured in numbers, showing the share of people who are unable to consume the minimum level of energy (FAO)[4]
Capital (K)	Gross capital formation (constant 2010 US$)
Labour force (L)	Labour force participation rate, total (percentage of total pop ages 15+)
Education (SEC)	Secondary school enrollment, (% of POP)
Education (TER)	Tertiary school enrollment (% of POP)

5.1. Descriptive Analysis

Table 2 demonstrates the descriptive statistic of data that is utilised for productivity and health analysis. The minimum WP is 2221.44 and maximum is 120793.3, measured as income per person in dollars. The minimum LE is 45.841 years and the maximum is 79.831 years in MIC. The minimum UND is 2.5 which means 2.5% POP is under sufficient dietary level and the maximum value is 42.2. The details of the remaining variables are given in Table 2.

Table 2: Summary Statistics of Data

Variables	Obs.	Mean	Std. Dev.	Min	Max
WP	1950	22749.66	15904.31	2221.444	120793.3
L	1950	60.3076	9.274711	39.146	85.393
K	1654	64713257037	2.91E+11	-949892745813	4570849659770
SEC	1400	70.3180	22.5913	13.15913	126.054
TER	1271	25.7592	18.6891	0.7758	103.7451
LE	1943	67.269	7.2590	45.841	79.831
UND	1183	11.8824	8.4755	2.5	42.2

[3] Stands for Population
[4] Food and Agriculture Organization of UN http://www.fao.org/sdg-progress-report/en/#sdg-2

5.2. Correlation among Variables

The positive value of the correlation coefficient indicates that both variables move in the same direction, while a negative value indicates that both variables move in the opposite direction.

Table 3 reveals that WP is positively correlated with LE, which means LE is a source of increasing WP, while it is negatively correlated with UND. In regards to correlation with other variables, we came to know that WP is positively correlated with all variables except labour. It shows the increasing rate of L participation decreases its WP; Siddique and Majeed (2015) also found an inverse relation among labour and per capita GDP.

Table 3: Correlation Matrix

Variables	WP	L	K	SEC	TER	LE	UND
WP	1						
L	-0.54	1					
K	0.03	0.10	1				
SEC	0.52	-0.17	0.11	1			
TER	0.52	-0.18	0.04	0.73	1		
LE	0.46	-0.29	0.13	0.65	0.55	1	
UND	-0.54	0.34	-0.04	-0.58	-0.58	-0.60	1

5.3. Graphical Analysis

This section portrays the graphical relationship between the worker's productivity and health. Figures 2 and 3 are depicting the relationship between "health and productivity" for MIC over 1991-2016.

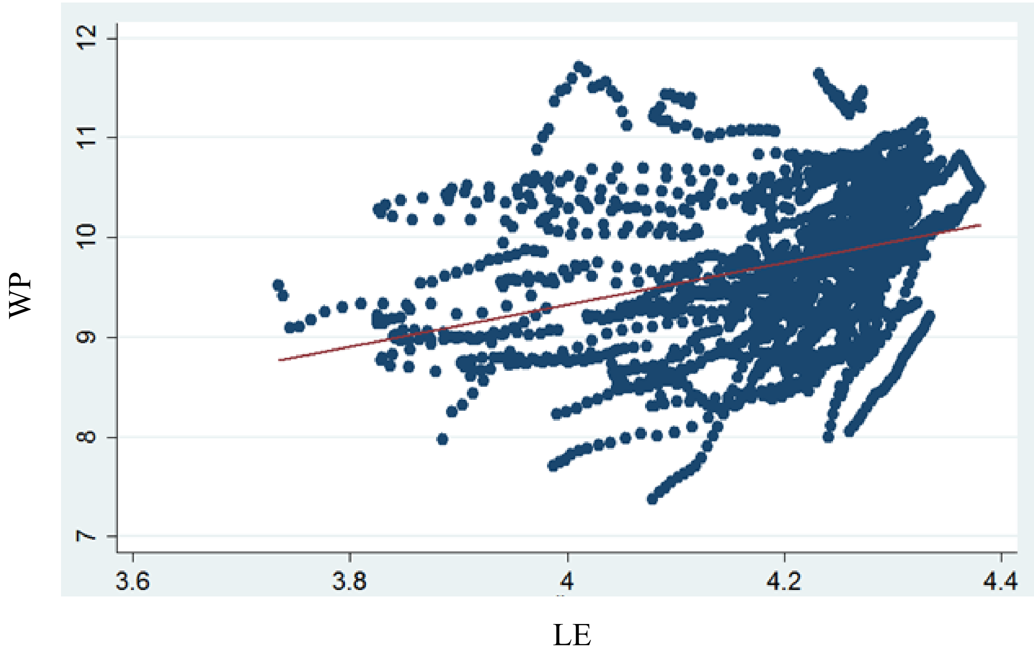

Figure 2: Relationship between Life Expectancy and Worker Productivity

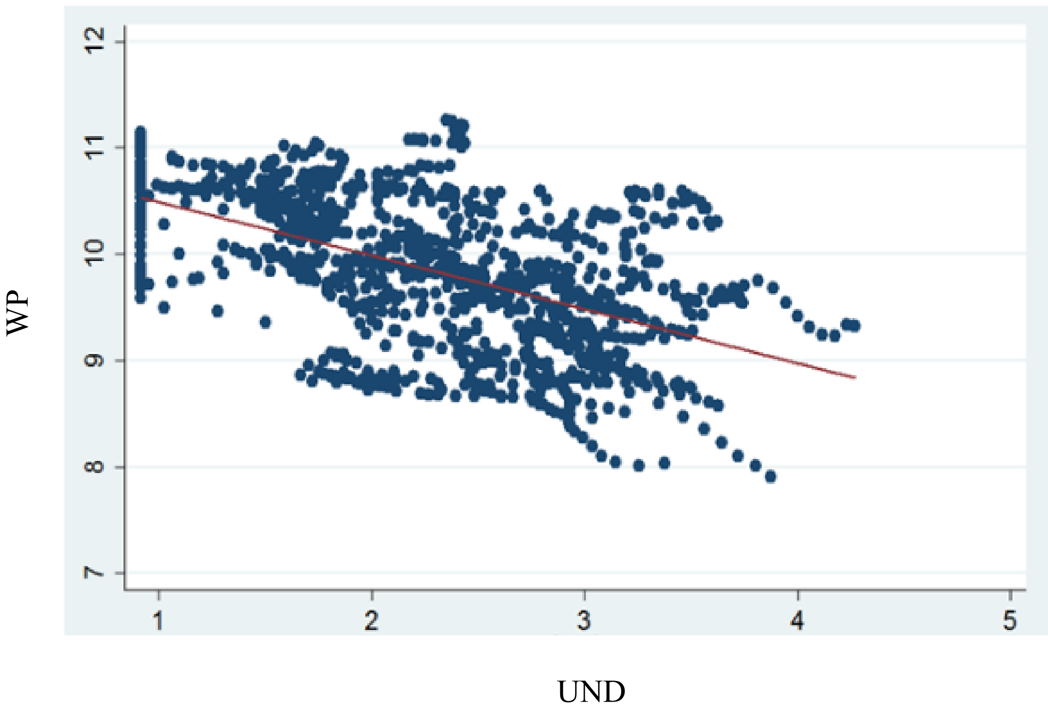

Figure 3: Relationship between Undernourishment and Worker Productivity

It is apparent from figures that there is a positive association between WP & LE, whereas there is a negative relationship between WP and UND. This signifies that health improvement enhances productivity.

6. Results and Interpretation

To choose with the estimation technique is fitting; in this case we used the Hausman test. We employed the Hausman test for each model. Results are presented in Table 4. It can be seen that in each regression, P-values are less than the significance level, so the null hypothesis “RE model is more apposite” is rejected. This indicates that in this case the FE model is suitable for all samples.

Table 4: Hausman Test Result

MIC (full sample)			
Model	**Chi-sq.**	**Prob.**	**Status**
1	26.87	0.0000	Fixed effects (FE) model
2	28.25	0.0000	FE
3	114.88	0.0000	FE
4	71.68	0.0000	FE
UMIC			
1	76.31	0.0000	FE
2	52.48	0.0000	FE
3	135.53	0.0000	FE
4	90.45	0.0000	FE
LMIC			
1	28.92	0.0000	FE
2	10.18	0.0374	FE
3	38.10	0.0000	FE
4	12.55	0.0137	FE

Note: The detail of used equations (19.1-19.4) are discussed in Section 3

6.1. Full Sample Results (MIC)

A fixed effects technique is used to analyse the impact of health on worker productivity for 75

MIC for 1991-2016. The study uses the variables in logarithm form[5]. Table 5 present the estimated results of model 1 and 2 (*p* and *le*) and model 3 & 4 (*p* and *und*) with both proxies of education.

Results of model 1 revealed that *le* has a significant and favorable impact on *p,* the coefficient shows a 1% increase in life expectancy which causes a 0.918% increase in output per worker, Arora (2001) also found this. Results show that capital and secondary education have a positive impact on productivity (e.g., Umoru and Yaqub, 2013), while labour is inversely related with output per worker. Siddique and Majeed (2015) also found a negative nexus among labour and per capita income. Results of model 2 expressed that *le* and *te* has a positive effect on *p,* while labour is inversely related to *p.*

Model 3 shows that undernourishment is a decreasing factor of *p.* Fogel (1997), and Cole and Neumayer (2006) also found that *und* decreases the productive capacity of labour. Results also exposed that *se* and *k* are the increasing factors of *p*. To the extent that labour force participation has a negative, while physical capital and education have positive coefficients. Increase in labour force participation is associated with diminishing output per person, whereas increases in capital and education tend to increase worker's performance. In model 4, the study measured that *und* reduces worker aptitude while the coefficient of *te* shows an increasing trend of education on *p.*

It is concluded that education and health are the main factors to enhance production capabilities while an increasing labour force participation rate decreases *p* in MIC. Our results are consistent with Ngangue & Manfred (2015), Umoru and Yaqub (2013), Tampa (2002) and Adedayo and Anthony (2016).

Table 5: Results of FE Model for Full Sample

Dependent Variable: p				
Variables	**(1)**	**(2)**	**(3)**	**(4)**
l	-1.290***	-1.030***	-1.098***	-0.969***
	(-13.03)	(-9.40)	(-9.17)	(-7.89)
k	0.189***	0.184***	0.254***	0.243***
	(21.15)	(19.33)	(23.82)	(19.57)
le	0.918***	0.416**		
	(7.15)	(2.89)		
und			-0.096***	-0.145***

[5] Models 1-4 are explained in Section 4.1 as Eq. 20.1-20.4

			(-6.52)	(-9.18)
sec	0.166^{***}		0.138^{***}	
	(6.62)		(4.95)	
ter		0.164^{***}		0.085^{***}
		(12.30)		(6.18)
C	6.227^{***}	7.545^{***}	8.139^{***}	8.251^{***}
	(10.11)	(11.30)	(14.41)	(14.60)
n	1225	1144	821	795

Note: t statistics in parentheses * $p < 0.05$, ** $p < 0.01$, *** $p < 0.001$

6.2. Subsample Results

In this section, the results for both subsamples UMIC and LMIC are presented one by one. The results attained from the FE method are shown in Table 1.6 and 1.7 for UMIC and LMIC, respectively.

6.2.1. Results of the FE Model for UMIC

Table 6 carries the findings for UMIC. Model 1 found that a 1% increment in *le* is expected to increase *p* by 1.178% in UMIC, (e.g., Knowles and Owen, 1997). Adeshina et al. (2019) also found the direct role of health on growth. Results also found that labour force participation has a negative, while capital has a positive coefficient. Increase in labour force participation is linked with shrinking output per person, whereas increases in *k* and *se* tend to increase *p*. Model 2 explains that *le, ter* and *k* are the increasing factors of *p*, while *l* is the source to decline *p* in UMIC.

Results of model 3 show that *und* as a health measure is declining *p;* Neumayer (2006) found the same consequences in his study. It is also found that *sec* and *k* improve the performance of labour. In model 4, the study found that *und* and *l* have bad impacts on *p,* while *k* and *ter* are the sources of enhancement in *p.*

Results expressed that both education and health are the main elements to improve *p* in UMIC. It is concluded that an increasing labour force participation rate decreases the *p*. Results are similar to the previous literature (e.g., Cole and Neumayer, 2006; Fogel, 1997; Umoru and Yaqub, 2013; Tallinn, 2006; and Mayer, 2001).

Table 6: Results of FE Model for UMIC

Dependent Variable: p				
Variables	**(1)**	**(2)**	**(3)**	**(4)**
l	-1.159***	-0.969***	-1.088***	-1.073***
	(-9.55)	(-6.74)	(-7.84)	(-7.42)
k	0.208***	0.206***	0.271***	0.277***
	(17.46)	(15.28)	(18.63)	(14.88)
Le	1.178***	0.549*		
	(5.94)	(2.13)		
und			-0.104***	-0.147***
			(-5.88)	(-7.74)
sec	0.152***		0.152***	
	(4.41)		(3.49)	
ter		0.157***		0.088***
		(7.33)		(4.02)
C	4.422***	6.479***	7.872***	8.084***
	(5.01)	(6.20)	(11.86)	(12.03)
N	709	629	479	442

Note: (a) t-values in parentheses (b) ***p<0.01, **p<0.05, *p<0.1

6.2.2. Results of the FE Model for LMIC

Table 7 carries the findings for LMIC. The study found an accelerating impact of health on productivity in LMIC. Model 1 revealed that a 1% increase in *le* improves productivity by 0.845%, Adeshina et al. (2019) also found the direct role of health on growth. Further, this study found that *sec* and *k* are helpful to enhance *p* whereas *l* has an adverse impact on *p* in LMIC. Model 2 explains that *le, ter* and *k* are increasing factors of *p*, while *l* is decreasing *p.* In model 3, health is measured by undernourishment and the sign of *und* is according to the literature. Results show that a 1% increase in *und* reduces *p* by 0.063% (e.g. Neumayer, 2006).

It is also found that *sec* and *k* improve the performance of labour. In model 4, the study found that *und* and *l* have inversely related to *p,* while *k* and *ter* are the sources of improvement in *p.* The results stated that education and health care are essentials to improve *p* and an increasing labour force participation rate falls *p* in LMIC. Results are similar to the studies of Fogel (1997), Cole and Neumayer (2006), Tallinn (2006) and Umoru and Yaqub (2013).

Table 7: FE Model Results for LMIC

Dependent Variable: p				
Variables	**(1)**	**(2)**	**(3)**	**(4)**
l	-1.863***	-1.399***	-1.262***	-0.958***
	(-10.23)	(-7.78)	(-5.16)	(-3.83)
k	0.145***	0.141***	0.239***	0.211***
	(11.10)	(11.08)	(14.75)	(12.16)
le	0.845***	0.432**		
	(5.29)	(2.85)		
und			-0.063*	-0.147***
			(-2.29)	(-5.02)
sec	0.172***		0.142***	
	(4.83)		(3.93)	
ter		0.167***		0.079***
		(10.84)		(4.56)
c	9.509***	9.662***	8.707***	8.654***
	(10.31)	(10.34)	(7.56)	(7.48)
n	516	515	342	353

Note: (a) t-values in parentheses (b) ***p<0.01, **p<0.05, *p<0.1

6.2.3. Summary of Subsample Results

It can be noted that the favorable effect of life expectancy on productivity is greater in case of UMIC, in comparison to LMIC, whereas the adverse impact of undernourishment is greater for

LMIC. This indicates that the impact of improved human health on output per person is stronger in UMIC than in LMIC. This may be due to already poor health conditions in LMIC.

7. Conclusion

The study is focused to scrutinise the role of human health measured by life expectancy and prevalence of undernourishment on labour productivity proxied by output per person employed in MIC. To accomplish this purpose, we used panel OLS, the fixed and random effects estimation technique. The study formulated a model using an aggregate production function. In our analysis of health and productivity, we have used both a full sample of MIC and subsamples of LMIC and UMIC over 1991-2016. Several conclusions drawn from this study are mentioned below.

This investigation empirically supports the theory that improvement in human health has a progressive effect on output per person. For the full sample, we found that there is a positive and significant relationship between life expectancy and productivity, while a negative and significant association between undernourishment and productivity. This means that an increase in life expectancy is expected to increase labour output, whereas the prevalence of undernourishment decreases productivity. In case of subsamples, the study found the same results regarding the impact of health.

An additional imperative finding of this study is that the impact of improvement in health on productivity is greater in UMIC in comparison to LIMC.

Concerning the influence of control variables, we found that an increase in the labour force participation rate is linked with diminishing productivity. Physical capital and education have a favourable and significant effect on productivity. These results are supported by McGuckin and Van Ark, 2005, Barro and Lee 2015 & Downes, A. S., 2001.

This study undergoes several limitations. The study has investigated the productivity impact of physical health only ignoring mental health. So, further investigation can be carried out by using mental health as a measure of health status. This study does not take into account reverse causality running from productivity to health, so future analysis can be conducted by taking into account potential endogeneity between the variables concerned.

Human health may have a drastic impact on the macro-economic performance of a country. So, this study calls for a worldwide commitment to deal with health problems. Increased investment in health-related services will improve health status in developing nations. Also, policies concerning physical capital and education must be prioritised as this study has established that these factors are linked to increased productivity.

REFERENCES

Adedayo, O. A., & Anthony, E. A. (2016). *Threshold Effects between Longevity, Labour Productivity and Economic Growth in sub-Saharan Africa (SSA): a Non-dynamic Panel Data Analysis.* 3rd International Conference on African Development Issues (CU-ICADI 2016), 475-480.

Adeshina, K. F., Adewale, O. H., Elvis, O., & Emile, N. (2019). Health Status, Labour Productivity and Economic Growth in Nigeria. *Journal of Economics, Management and Trade*, *23*(1), 1-12.

Arora, S. (2001). Health, human productivity, and long-term economic growth. *The Journal of Economic History*, *61*(3), 699-749.

Barro, R. J. (1991). Economic Growth in a Cross Section of Countries. *The Quarterly Journal of Economics*, *106*(2), 407-443.

Barro, R. J., & Lee, J. W. (2015). *Education matters. Global schooling gains from the 19th to the 21st century*. Oxford University Press.

Becker, G. S., Murphy, K. M., & Tamura, R. (1990). Human capital, fertility, and economic growth. *Journal of Political Economy*, *98*, 12-37.

Bhargava, A., Jamison, D. T., Lau, L. J., & Murray, C. J. (2001). Modeling the effects of health on economic growth. *Journal of health economics*, *20*(3), 423-440.

Bloom, D. E., & Canning, D. (2000). The Health and Wealth of Nations. *Science*, *287*(5456), 1207-1209.

Bloom, D. E., Canning, D., & Sevilla, J. (2004). The Effect of Health on Economic Growth: A Production Function Approach. *World development*, *32*(1), 1-13.

Bloom, D. E., Canning, D., Kotschy, R., Prettner, K., & Schünemann, J. J. (2019). *Health and Economic Growth: Reconciling The Micro And Macro Evidence* (No. w26003). National Bureau of Economic Research.

Bloom, D., Canning, D., & Sevilla, J. (2002). *Health, Worker Productivity, and Economic Growth*. In 13th annual Health Economics Conference, 1-31.

Bound, J. (1989). *Self-reported vs. Objective Measures of Health in Retirement Models* (No. w2997). National Bureau of Economic Research.

Choudhry, M. T. (2009). *1 Determinants of Labour Productivity: An Empirical Investigation of Productivity Divergence.* Working paper, University of Groningen.

Cole, M. A., & Neumayer, E. (2006). The impact of poor health on total factor productivity. *The Journal of Development Studies*, *42*(6), 918-938.

Downes, A. S. (2001). Education, Productivity and the Economic Development of Barbados. *Caribbean Quarterly*, *47*(2/3), 1-19.

Fogel, R. W. (1997). New Findings on Secular Trends in Nutrition and Mortality: Some Implications for Population Theory. *Handbook of population and family economics*, *1*(Part A), 433-481.

Gupta, I., & Mitra, A. (2004). Economic growth, health and poverty: An exploratory study for India. *Development policy review, 22*(2), 193-206.

Harris, R. G. (1999). *Determinants of Canadian productivity growth: Issues and Prospects*. Ottawa, ON: Industry Canada.

Knapp, D. (2007). *The Influence of Health on Labour Productivity: An Analysis of European Conscription Data* (Doctoral dissertation). The Ohio State University.

Knowles, S., & Owen, P. D. (1997). Education and Health in an Effective-Labour Empirical Growth Model. *Economic Record*, *73*(223), 314-328.

Levine, R., & Renelt, D. (1992). A sensitivity analysis of cross-country growth regressions. *The American Economic Review, 82*(4), 942-963.

Madsen, J. B. (2016). Health, Human Capital Formation and Knowledge Production: Two Centuries of International Evidence. *Macroeconomic Dynamics*, *20*(4), 909-953.

Mayer-Foulkes, D. (2001). The Long-Term Impact of Health on Economic Growth in Latin America. *World Development*, *29*(6), 1025-1033.

McGuckin, R., & van Ark, B. (2005). *Productivity and Participation: An International Comparison.* University of Groningen, GGDC Research Memorandum, 200578.

Ngangue, N., & Manfred, K. (2015). The Impact of Life Expectancy on Economic Growth in Developing Countries. *Asian Economic and Financial Review*, *5*(4), 653-660.

Ram, R., & Schultz, T. W. (1979). Life Span, Health, Savings, and Productivity. *Economic Development and Cultural Change, 27*(3), 399–421.

Schultz, T. P. (2005). *Productive Benefits of Health: Evidence from Low-Income Countries* (IZA Discussion Papers, No. 1482). Institute for the Study of Labour (IZA), Bonn.

Sengupta, K. (2017). Health and its Impact on Labour Productivity and Labour Market. *International Journal of Health and Medicine*, *2*(1), 13-16.

Shahid, A., Siddique, H. M. A., and Liaqat, R., (2019). Human Health and Foreign Direct Investment Nexus: Evidence from South Asia. *Asian Development Policy Review, 7*(3), 209-218.

Siddique, H. M. A., & Majeed M. T. (2015). Energy Consumption, Economic Growth, Trade and Financial Development Nexus in South Asia. *Pakistan Journal of Commerce and Social Science, 9*(2), 658-682.

Siddique, H. M. A., & Kiani, A. K. (2020). Industrial pollution and human health: evidence from middle-income countries. *Environmental Science and Pollution Research*, *27*(11), 12439-12448.

Siddique, H.M.A., Mohey-ud-din, G., and Kiani, A. K., (2018). Health, education, and economic growth nexus: Evidence from middle income countries. *Global Social Sciences Review, 3*(4), 68-86.

Skirbekk, V. (2003). *Age and Individual Productivity: A Literature Survey* (No. WP 2003-028). Max Planck Institute for Demographic Research, Germany.

Strauss, J., & Thomas, D. (1998). Health, nutrition, and economic development. *Journal of economic literature*, *36*(2), 766-817.

Soukiazis, E., & Cravo, T. (2007). *The Interaction between Health, Human capital and Economic Growth, Empirical Evidence, Casualty of Economics (*Discussion Paper*)*. Faculty of Economics, University of Coimbra (Portugal).

Tallinn (2006). *The Economic Consequences of Ill-health in Estonia*. World Health Organization Regional Office for Europe Ministry of Social Affairs, PRAXIS Centre for Policy Studies.

Thomas, D., Frankenberg, E., Friedman, J., Habicht, J. P., Hakimi, M., Ingwersen, N., & Sikoki, B. (2006). *Causal Effect of Health on Labour Market Outcomes: Experimental Evidence* (No. CCPR-070-06). California Center for Population Research On-Line Working Paper Series.

Tompa, E. (2002). *The Impact of Health on Productivity: Macro and Microeconomic Evidence and Policy Implications*. The Review of Economic Performance and Social Progress (Book), 181-202.

Umoru, D., & Yaqub, J. O. (2013). Labour productivity and health capital in Nigeria: The empirical evidence. *International Journal of Humanities and Social Science*, *3*(4), 199-221.

Weil, D. N. (2007). Accounting for the Effect of Health on Economic Growth. *The Quarterly Journal of Economics*, *122*(3), 1265-1306.

World Bank (1993). World Development Report 1993, Investing in Health (World Bank).https://www.tandfonline.com/doi/abs/10.1080/08039410.1993.9665939?journalCode=sfds20

World Bank (2018), World Development Indicators (WDI), Online Database, Washington DC: World Bank Group, Available at http://databank.worldbank.org/.