The Impact of Carbon Dioxide Emissions on Human Development Index in MENA region

Submitted by

Alyaa Hamed Sallam

Prof.Dr. Sabry Ahmed Abou- Zaid
Prof.Dr. Nagwa Ali Khashaba
Prof.Dr. Beat Hintermann
Prof. Dr. Mohamed Kamal El- sayed

ABSTRACT

This study aims to investigate the impact of carbon dioxide emissions associated with energy consumption on the human development index in twenty-eight MENA Countries- including Egypt for the period (1990- 2018). Random-effects models and the difference-generalized method of moment (DIF-GMM) estimators of Arellano and Bond (1991) are employed. The empirical results show that carbon dioxide emissions have a positive impact on HDI in MENA region

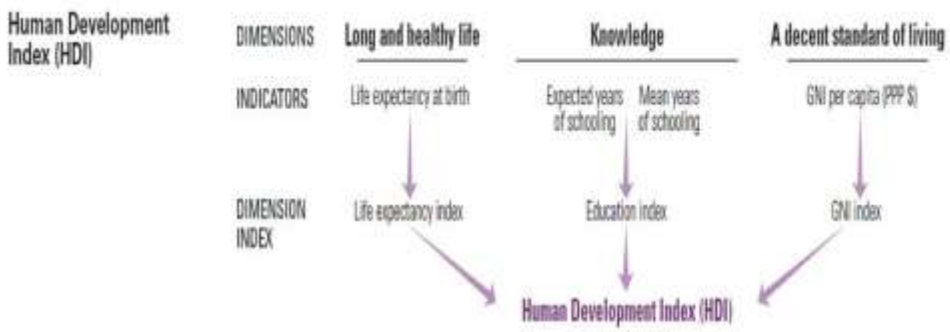
Keywordsords: Carbon dioxide emissions; Human development index; Economic growth; Health and Education

1. Introduction

This study analyzes the impact of carbon dioxide emissions on the human development index and the human development index, using panel data analysis for 28 MENA countries; namely, Afghanistan, Algeria, Armenia, Azerbaijan, Bahrain, Cyprus, Djibouti, Egypt, Ethiopia, Georgia, Iran, Iraq, Jordan, Kuwait, Lebanon, Libya, Mauritania, Morocco, Oman, Pakistan, Palestine, Qatar, Saudi Arabia, Sudan, Syria, Tunisia, Turkey, and the United Arab Emirates for the period 1990 to 2018.

The dependent variable in this study is ***the human development index*** as a proxy for human development and welfare that highlights the prosperity and quality of life. The HDI is defined as a summary measure of average achievement in the three key dimensions of human development: having a decent standard of living, a long and healthy life, and being knowledgeable. The human development index is the geometric mean of normalized indices for each one of the three dimensions (UNDP, 2020c). It ranges from 0 to 1, where 0 is the lowest level of human development while 1 is the highest one (UNDP, 2020c). The components of HDI are presented in figure (1).

Figure (1): The components of HDI



Source: (UNDP, 2020c)

There are interrelationships between the three dimensions of HDI; For instance, The Human Capital Theory conceptualizes education as an investment that provides returns via increased productivity (Becker, 2009). Also, Education improves individuals' skills, knowledge, effectiveness, reasoning, and a wide range of other capabilities, which can be utilized to improve health (Mirowsky & Ross, 2017).

The Fundamental Cause Theory posits that social factors such as education are major determinants for health and disease as they determine access to a multitude of material and non-material resources such as income, healthier lifestyle, and safe neighborhoods, all of which could enhance or protect health (Link & Phelan, 1995).

In general, most health outcomes are found strongly patterned by education. Less educated people report worse general health (Johnson-Lawrence et al., 2017), more chronic conditions (Johnson-Lawrence et al., 2017), and more functional disability and limitations (Zajacova & Montez, 2017). Furthermore, poor health in childhood may lead to lower education levels, and indicators such as low birth weight (predictor for childhood health) suggest lower test scores and lower education levels (Zimmerman et al., 2015).

Also, Education leads to better and more stable jobs that pay higher income and allow families to accumulate wealth that can be used to improve health (Zimmerman et al., 2015). Actually, economic factors are an important link between schooling and health, estimated to account for about 30% of the correlation (Pollack, 2008).

As another example of the interrelationships between the variables, (Eren et al., 2014) shows that increasing GNI may improve the quality of education and health. It has generally been well accepted that populations in countries with higher levels of GDP will have better health and longer life expectancy, as higher living standards lead to enhanced prevention and treatment of diseases and healthcare spending (Swift, 2011).

Carbon dioxide emissions associated with energy consumption are the main variable in this study. ***CO2 emissions in this study are measured as per capita CO2 emissions***.

Channels through which carbon emissions affect human development:

Energy is the golden thread connecting economic growth, social equity, and environmental sustainability (Qin Li and Chen, 2021). In this context, energy consumption is also a bridge connecting the relationship between human development and carbon dioxide emissions. On one way, the level of human development depends on the satisfaction of humans' own needs and the energy consumption is often the strong support behind it. On the other way, energy consumption is also the main source of carbon dioxide emissions including CO2 emissions generated by the direct energy consumption of residents such as heating, cooling, lighting, transporting, cleaning, cooking, and indirect energy consumption caused by the consumption of products and services (Pachauri et al., 2004).

Macroeconomists typically emphasize two direct channels through which energy consumption and the associated CO2 emissions are deemed to affect human development; the first one is through the effect on economic growth and the second channel is through the effect on health.

The relationship between energy and economic growth is explain via energy-economic growth nexuses as follow:

Neoclassical and endogenous growth models analyzed the impacts of primary production factors (i.e. capital and labor) on economic growth. Energy and the type of energy employed in the production process are frequently ignored or most probably regarded as an intermediate input. In this way, an implicit role can be given to energy as an input in the growth process. According to the neoclassical model by (Solow, 1956), the cause of continuing economic growth is technological progress which is an exogenous factor.

Later on, endogenous growth models attempt to explain technological progress within the growth model as the outcome of decisions taken by firms and individuals (Stern, 2000). Technology is seen as an endogenous factor that could be related to energy. Most technology as given per time is depending on the availability of useful energy to power it. Plants, machinery, and the likes are examples of technology referred to. Without supplying adequate energy (in this case electricity or petroleum), these technologies are practically useless. The law of thermodynamics helps to justify this by stating that “no production process can be driven without energy conversion”. Energy is not the single factor determining technology but is a necessary element to ensure that technology (at whatever level) is being utilized (Adenuga & Emeka, 2013).

Therefore, Energy consumption is beneficial to economic growth, thereby influencing people’s income, standards of living, and purchasing power (Bildirici & Özaksoy, 2018).

Following existing empirical studies, six control variables were added to the model to prevent variable omission bias; namely, public spending as a percentage of GDP (PS), gross fixed capital formation as a percentage of GDP (I), Foreign direct investment as a percentage of GDP (FDI), the sum of exports, and imports as a percentage of GDP (TRA), consumer price index which serves as the proxy for aggregate price level (CPI) and urban population as a percentage of total population (URB).

Public spending as a percentage of gross domestic product is one of the control variables. Its expected impact on HDI is positive. (Leitner & Stehrer, 2016) found that higher levels of public expenditures are correlated with healthier people, higher educational levels of the youth population, and higher employment rates. Public expenditures on health and education are much more productive than others in terms of achieving advances in human development (Ray, 2011). public expenditures on health (for diseases prevention, medical treatment, or healthcare) should enhance the health status of the people and thus life expectancy, while public Investments in the skills of the people should have a wide range of effects; for instance, an increase in productivity and income levels (Leitner & Stehrer, 2016).

Gross fixed capital formation as a percentage of GDP is another control variable in this study, as an indicator of investment. It's expected that investment has a positive effect on HDI. The empirical literature supports the positive impact of investment on economic growth and employment rate (e.g.,(Ilegbinosa et al., 2015; Kalu & Onyinye, 2015; Suhendra & Anwar, 2014).

These improvements in society may stimulate the human development process. It increases GNI and the purchasing power of people, and in the end, could improve the quality of education and health. Moreover, private investment in infrastructure, education, and the healthcare system have a strong impact on the three aspects of HDI (Kusharjanto & Kim, 2011).

Also, ***Foreign direct investment as a percentage of gross domestic product*** is considered a major determinant for human development. Its impact on HDI is still a matter of debate.

Regarding ***trade openness***, it could be an important engine of human development, particularly when liberalized trade systems provide an environment conducive to growth (Rodrik, 1999). Trade openness measures the impact of changes in international prices on the income position of domestic people (Andersen & Babula, 2009).

This captures the idea that an economy with a high degree of openness has the merit of increasing the volume of commerce, which can increase per capita incomes under conditions of favorable terms of trade (Thirlwall, 2012). It also creates more employment opportunities in the country, thereby helping to increase per capita income (Wang et al., 2018). ***Trade Openness in this study is measured by the ratio of exports plus imports to GDP.***

The consumer price index as a measure of inflation is used as a control variable. The empirical literature supports the negative impact of CPI on energy HDI; for instance, (Naz et al., 2011) found that inflation can disrupt business planning, employment, nutrition, education, and children's health.

(Osiakwan & Armah, 2013) found that inflation has a negative and significant impact on the standards of living and HDI. In addition, the rises in energy prices are reported to have harmful welfare consequences in the lower-income group (Romero-Jordán et al., 2016). Although, energy consumption is generally important for both the rich and the poor, however, the increase in energy prices impacts the standard of living of the poor compared to the rich (Balachandra, 2011).

Urbanization is expected to have a positive impact on HDI via several potential channels. Higher urbanization provides more employment opportunities, higher productivity, higher wages, localized technology spillovers, access to better-quality goods, efficiency benefits, and improved access to basic services such as health and education (Tripathi, 2021). Several studies; (Baldwin & Martin, 2004; Brülhart & Sbergami, 2009; Tripathi, 2013) found that urbanization has a positive link with higher per capita gross domestic product (GDP). Moreover, urbanization has better access to medical care, better education opportunities, and improved socioeconomic infrastructure which have a positive impact on health and hence life expectancy and to some extent on education (Kalediene & Petrauskiene, 2000). Therefore, the urban population is a major indicator of life expectancy and education in both developing and developing countries' perspectives. (Solarin et al., 2016). ***The study uses the urban population as a percentage of the total population***.

In addition, these dependent variables are used to estimate the impact of CO2 emissions on each indicator of the HDI dimensions: GNI per capita, life expectancy, and expected years in schooling.

The second dependent variable employed in this study is gross national product per capita, PPP (constant 2017 international $) as a proxy of the standard of living. The third dependent variable is life expectancy at birth (LE) as a proxy of health and it is defined as the number of years a newborn infant could expect to live if prevailing patterns of age-specific mortality rates at the time of birth stay the same throughout the infant’s life (UNDP, 2020c). The fourth dependent variable used in the model is the expected years of schooling (EYS) as a proxy of education and it is defined as the number of years of schooling that a child at school entrance age is expected to receive if prevailing patterns of age-specific enrolment rates persist throughout his/her life (UNDP, 2020c).

2. Descriptive Data Analysis

This study uses an unbalanced panel dataset of 28 MENA countries for the period 1990 to 2018 to look for the impact of CO_2 emissions on human development. The Selection of the sample period and the subset of MENA countries are based on the availability of the data.

Table (1) provides an overview of the data used in the estimation. The large divergences between the minimum and the maximum values of the variables in the dataset indicate an obvious heterogeneity of the years and countries. For instance, the Human development index ranges from 0.292 to 0.919. This is mainly because the region includes high-income countries (such as the Arab Gulf countries), middle and lower-income countries (such as Egypt and Morocco), and low-income courtiers (such as Ethiopia and Sudan). They have different social, political, and economic circumstances.

Table (1): Descriptive statistics of the variables over the period 1990 to 2018 for 28 MENA countries.

Variable	Obs	Mean	Std. Dev.	Min	Max
HDI	751	.6637364	.1441427	.292	.916
GNI	521	17978.13	18256.04	1358.033	103519.1
CO2	800	7.039353	9.093087	.0295584	47.69993
PS	692	16.11795	6.334909	2.331687	76.22213
I	650	23.19628	8.004481	.7344631	57.71025
FDI	765	5.074527	18.99686	-25.1082	280.1318
TRADE	702	80.2231	39.57952	.0209992	347.9965
CPI	719	88.18329	77.24285	.0305676	1344.193
UPOP	803	64.69464	21.51332	12.621	100
POP	800	2.51e+07	3.58e+0	476275	2.12e+08

2. Empirical Methodology

To examine the relationship between CO2 emissions and HDI, the study followed the empirical specifications by (Poumanyvong & Kaneko, 2010) and (Paliova et al., 2019) with some modifications.

Model A:

$$\ln(HDI_{it}) = \tilde{\alpha} + \beta 1 \ln(CO2_{it}) + \beta 2PS_{it} + \beta 3I_{it} + \beta 4FDI_{it} + \beta 5TRA_{it} + \beta 6\ln(CPI_{it}) + \beta 6URB_{it} + \varepsilon_{it}$$

where subscripts i and t denote country and year respectively. ln(HDI)

represents human development index in logs; ln(CO2) represents carbon emissions per capita in logs, PS represents public spending as a percentage of GDP, I represents gross fixed capital formation as a percentage of GDP, TRA is the degree of trade openness which is measured as the sum of exports and imports as a percentage of GDP, ln(CPI) is consumer price index which serves as the proxy for the aggregate price level, Urb is urban population as a percentage of the total population. $\bar{\alpha}$ is the fixed intercept and ε_{it} is the error term that is called the combined error term because it includes the random individual differences which are called the random effects. the random-effects model is used due to the results of the Hausman test as shown in the model specification section.

Before setting up the estimation models, some preliminary tests are applied to the data as follows:

Panel Unit root tests

Four different panel unit root tests are utilized, namely; (Levin et al., 2002) (LLC), (Im & Pesaran, 2003) (IPS), and (Breitung, 2001) (UB). The LLC test assumes that the autoregressive coefficient does not change in all units, the disturbance term is a stationary process and units are independent across all sections. LLC provides three specifications for the deterministic component; individual-specific component as well as a time trend, individual-specific component, and no deterministic component. The null hypothesis of the LLC test is that the variable has a unit root and the alternative hypothesis is that all individual series in the panel data don’t have a unit root.

Table (2): unit root tests for the variables at levels (sample of 28 countries during the period 1990 to 2018)

		Level			
Variables	LLC	BU	IPS	ADF	PP
ln(HDI)	1.64213	5.73210	2.14331	60.7840	35.5627
ln(CO2)	-1.9789**	4.46614	-1.484*	77.625**	99.5***
PS	-2.591***	-0.43656	-0.89518	70.5974*	75.89**
I	-2.855***	-1.69255**	-1.33052*	76.86**	48.9017
FDI	-2.587***	-5.24770***	-4.10252*	104***	133 ***
TRA	-0.99784	-2.77004***	-0.57047	65.9649	58.3351
ln(CPI)	0.38287	-1.02661	-2.50488***	118.4***	803.5***
URB	11.30***	-6.4***	-1.78638**	410.285***	592.4***
ln(GNI)	0.02689	-0.08598	47.63	36.1979	36.1979

The LL, UB, IPS, Fisher-ADF and Fisher-PP examine the null hypothesis of non-stationarity. *** , ** and* indicate statistical significance at the 1% , 5% and 10% level, respectively. Probabilities for Fisher-type tests were computed by using an asymptotic x2 distribution. All other tests assume asymptotic normality. Automatic lag length selection based on AIC. Source: Author's calculation.

Table (3): unit root tests for first difference variables (sample of 28 countries during the period 1990 to 2018)

	First Difference				
Variables	LLC	BU	IPS	ADF	PP
ln(HDI)	-13.7510***	-3.812***	-13.1***	291.896***	540.278***
ln(CO2)	-10.43***	-4.3***	-11.9***	259.884***	986.084***
PS	-13.8***	-8.004***	-10.53***	303.237***	442.935***
I	-11.13***	-8.99***	-6.80***	216.711***	261.881***
FDI	-16.70***	-12.89***	-17.80***	450.802***	1341.13***
TRA	-17.6****	-6.82504***	-11.67***	432.237***	396.140***
ln(CPI)	-49.71***	-2.09****	-17.54***	502.731***	802.652***
URB	-6.28765***	3.06916	-10.28***	372.598***	638.530***
ln(GNI)	8.26***	4.37***	-4.99***	163.865***	230.258***

The LL, UB, IPS, Fisher-ADF, and Fisher-PP examine the null hypothesis of non-stationarity.

*** , ** and* indicate statistical significance at the 1% , 5% and 10% level, respectively. Probabilities for Fisher-type tests were computed by using an asymptotic x_2 distribution. All other tests assume asymptotic normality. Automatic lag length selection based on AIC. Source: Author's calculation.

Panel Cointegration test

Table (4): Cointegration tests for the variables (the sample of 28 countries during the period 2004-2016)

	Pedroni Residual Cointegration Test		Kao Residual Cointegration Test
	Panel	Group	
Panel v-Statistic	10.93249***		
Panel rho-Statistic	2.863336	6.401437	
Panel PP-Statistic	-6.0148***	-6.2936***	
Panel ADF-Statistic	-1.202	-3.0106***	
ADF			-3.644328***

Note: V, non-parametric variance ratio statistic; p, non-parametric test statistic analogous to the Phillips and Perrron (PP) rho statistic; PP non-parametric statistic analogous to the PP t statistic; and ADF, parametric statistic analogous to the augmented Dickey- Fuller statistic. All statistics are distributed as standard normal as T and N grow large. Null hypothesis: no cointegration

*** denote 1% of significance.

** denote 5% of significance.

Source: Author's own calculation.

Hausman test is employed to choose between the fixed effects and random effects models. The null hypothesis is accepted. The results of the Breusch and Pagan Lagrangian Multiplier test for random effects rejected the null hypothesis that the Pooled OLS model is appropriate. So the best model to choose for model specification (A) is the random effect model.

Also, the test for including time-specific fixed effects does reject the null hypothesis of redundant cross-section random effects with time dummies. So random effects model with time dummies is applied.

Likelihood-ratio (LR) test indicates that heteroskedasticity is present in the model on the other hand, that the Wooldridge test for autocorrelation in panel data (Wooldridge, 2002) yields a clear indication of autocorrelation in the residuals. To solve these problems, White heteroscedasticity corrected standard errors are used.

To solve for potential endogeneity bias, which may be due to reverse causality from the dependent to independent variables or omitted variables in the model, I employ specification A1, in which the values of the explanatory variables are replaced by their one-year lagged value in the model. The reason is that causality could only go forward in time. If there is any feedback from the dependent variable to the independent variable, this could not be in the form of the impact of y (t) on x(t-1). Also, changes in the independent variables are not expected to affect the dependent variable immediately.

For proving the robustness of the econometric results and remedying any potential endogeneity problems, I employ the generalized method of movements (GMM) estimator of Arellano and Bond (1991) to re-estimate model (A). It provides a methodology for defining instruments that are appropriate for dynamic panel models by using a first differencing transformation to eliminate unobserved firm-specific heterogeneity. This model contains the lagged dependent variables ln (HDI_{t-1}).

The urban population will not be excluded from this model specification since GMM corrects the potential problem with multicollinearity. GMM is used when the order of integration of the variables are I(0) or I(1) or are a combination of I(0) and I(1).

3.Empirical results

Table (5): Empirical results of Model (A):

Specification Method	Random Effects	Radom Effects (Lagged explanatory variables)
Dependent Variable	ln*(HDI)*	Ln*(HDI)*
ln(CO2)	0.08695266***	0.086032***
PS	0.00133644	0.00130984
I	-0.00029305	-0.00033232
FDI	-0.00010845	-0.0001151
TRA	0.00008096*	0.00006748

ln(CPI)	0.00995886	0.00991436
N	594	571
Prob (F -stat.)	0.001	0
r2_adjusted	.8011	.799

legend: * p<0.1; ** p<0.05; *** p<0.01

Table (6): Empirical results of GMM estimation for model (A):

Specification Method	GMM
Dependent Variable	ln*(HDI)*
ln(HDI) -1	.9648892***
ln(CO2)	0.0144178**
PS	0.0004382
I	-0.0000269
FDI	-0.0000008
TRA	0.0000342
ln(CPI)	-0.0060395**
URB	-0.0014315
N	479
Long run effect (S)	0.4106
Sargen statistic	480.2462
AR(1)	-3.732***
AR(2)	-0.23864

legend: * p<0.1; ** p<0.05; *** p<0.01

In the first column of Table (5), the results of model (A) without lagged regressors are reported. It reveals that the impact of carbon dioxide emissions on the human development index is positive and statistically significant. A 1 percent increase in carbon dioxide emissions per capita leads to an approximately 0.087% increase in the human development index at a 1% significance level in the 28 MENA countries.

Column 2 of table (5) reports the results of model (A) with the lagged regressors. The result did not differ much in both Models. It shows that for every 1 percent increase in carbon dioxide emissions per capita, the human development index increases by around 0.086% at a 1% significance level.

Table (6) presents the results of (DIFF- GMM) for model (A). The result of the AR(2) test indicates that there is no second-order autocorrelation in first differenced errors at conventional significance levels. on the other hand, the result of sargan test indicates that the null hypothesis of over-identifying restrictions is valid is not rejected at conventional significance levels. These results indicate that the dynamic panel data model used is a good specification.

The results show that per capita CO2 emissions have positive and statistically significant effects on HDI at a 5% significance level. The coefficient of per capita CO2 is approximately .01 implying that a 1% increase in the per capita CO2 emissions increases HDI by approximately 0.01% for sample countries. Furthermore, the results show that CO2 emissions have a significant positive impact on HDI in the long run. A 1 percentage point increase in per capita CO2 leads to an increase in HDI by 0.4106% in the 28 MENA countries.

References

Baldwin, R. E., & Martin, P. (2004). Agglomeration and regional growth. In Handbook of regional and urban economics (Vol. 4, pp. 2671-2711). Elsevier.

Becker, G. S. (2009). Human capital: A theoretical and empirical analysis, with special reference to education. University of Chicago press.

Brülhart, M., & Sbergami, F. (2009). Agglomeration and growth: Cross-country evidence. Journal of Urban Economics, 65(1), 48-63.

Eren, M., Çelik, A. K., & Kubat, A. (2014). Determinants of the levels of development based on the Human Development Index: A comparison of regression models for limited dependent variables. Rev. Eur. Stud., 6, 10.

Ilegbinosa, I. A., Micheal, A., & Watson, S. I. (2015). Domestic investment and economic growth in Nigeria from 1970-2013: An econometric analysis. Canadian Social Science, 11(6), 70-79.

Johnson-Lawrence, V., Zajacova, A., & Sneed, R. (2017). Education, race/ethnicity, and multimorbidity among adults aged 30–64 in the National Health Interview Survey. SSM-population health, 3, 366-372.

Kalediene, R., & Petrauskiene, J. (2000). Regional life expectancy patterns in Lithuania. The European Journal of Public Health, 10(2), 101-104.

Kalu, C. U., & Onyinye, M. O. (2015). Domestic private investment and economic growth in Nigeria: Issues and further consideration. International Journal of Academic Research in Business and Social Sciences, 5(2), 302.

Klugman, J. (2011). Human Development Report 2011. Sustainability and Equity: A better future for all. Sustainability and Equity: A Better Future for All (November 2, 2011). UNDP-HDRO Human Development Reports.

Kusharjanto, H., & Kim, D. (2011). Infrastructure and human development: the case of Java, Indonesia. Journal of the Asia Pacific Economy, 16(1), 111-124.

Leitner, S., & Stehrer, R. (2016). Development of public spending structures in the EU member states: social investment and its impact on social outcomes.

Link, B. G., & Phelan, J. (1995). Social conditions as fundamental causes of disease. Journal of health and social behavior, 80-94.

Mirowsky, J., & Ross, C. E. (2017). Education, social status, and health. Routledge.

Pollack, H. (2008). Making Americans healthier: Social and economic policy as health policy. Russell Sage Foundation.

Ray, S. (2011). Dynamic links between economy and human development: A study of Indian states

Solarin, S. A., Shahbaz, M., & Shahzad, S. J. H. (2016). Revisiting the electricity consumption-economic growth nexus in Angola: The role of exports, imports and urbanization. International Journal of Energy Economics and Policy, 6(3), 501-512.

Suhendra, I., & Anwar, C. J. (2014). Determinants of private investment and the effects on economic growth in Indonesia. GSTF Journal on Business Review (GBR), 3(3).

Swift, R. (2011). The relationship between health and GDP in OECD countries in the very long run. Health economics, 20(3), 306-322.

Tripathi, S. (2013). An overview of India's urbanization, urban economic growth and urban equity.

Tripathi, S. (2021). How does urbanization affect the human development index? A cross-country analysis. Asia-Pacific Journal of Regional Science, 5(3), 1053-1080.

UNDP. (2020). United Nations Development Program. http://hdr.undp.org/en/content/human-development-index-hdi

Zajacova, A., & Montez, J. K. (2017). Physical functioning trends among US women and men age 45–64 by education level. Biodemography and Social Biology, 63(1), 21-30.

Zimmerman, E. B., Woolf, S. H., & Haley, A. (2015). Understanding the relationship between education and health: a review of the evidence and an examination of community perspectives. Population health: behavioral and social science insights. Rockville (MD): Agency for Health-care Research and Quality, 347-384.