ORIGINAL ARTICLE

Social Determinants of Health: Analysis of the Effect of Socio-environmental Factors to Diseases, Injury-related DALYs, and Deaths based on WHO, ILO, and WB Data

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ABSTRACT

Introduction. The social determinants of health refer to an individual's social, political, and economic situation and environment, which can have an impact on their health. On the other hand, disability-adjusted life years (DALYs) reflect the mortalities and morbidities incurred due to disease and injury.

Objectives. This study aims to analyze the social determinants of health indicators and their association with communicable, non-communicable, and injury-related DALYs and deaths.

Methods. Data from World Health Organization, World Bank, and International Labor Organization were used and considered for the 17 Social Determinants of Health categories. Logistic regression was used to determine the relationship of social determinants of health indicators with communicable, non-communicable, and injury-related DALYs and deaths.

Results. Results show that an increase in the population, monetary poverty, adult illiteracy, and fine particulate matter increase IPNN DALYs. This study also found correlations of socioeconomic factors to NCD deaths and DALYs attributable to the environment. NCD DALYs and deaths are found to increase with the number of poor living with 3.10 dollars a day, while median daily per capita income, and increase in persons above retiring age receiving pension decrease NCD DALYs attributable to the environment. Focusing on injury DALYs and deaths, an increase in the number of poor living at 3.10 dollars a day, non-agricultural informal employment, and total average concentration of fine particulate matter increases injury DALYs while the latter is observed to decrease when there is an increase in the medial daily per capita income, agricultural employment outside the formal sector, and vulnerable persons covered by social assistance.

Conclusion. Socio-economic factors such as income, employment, education, and social welfare program affect morbidity, disability, and mortality.

Keywords: social determinants of health, disability-adjusted life years, injury, morbidity, mortality

INTRODUCTION

According to the World Health Organization (WHO),[1] disability-adjusted life years (DALYs) is "a time-based measure that combines years of life lost due to premature mortality (YLLs) and years of life lost due to time lived in states of less than full health, or years of healthy life lost due to disability (YLDs)." It reflects the mortalities and morbidities incurred due to disease and injury. The social determinants of health refer to the social, political, and economic situation

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and environment that an individual lives in and has the capacity to affect their health. It is impossible to discuss the causes of DALYs and deaths only through a biological perspective as disparities and health inequalities observed worldwide are socioeconomic in nature.[2]

The WHO reports that around 24% of deaths worldwide are associated with environmental conditions. In fact, the environment is considered a contextual determinant of health as it encompasses the physical, chemical, and biological factors that an individual is exposed to. An individual's environment is dependent on the social and political placement as these determine their access to clean water, safe housing, sanitation, and directly affect one's health.[3] To guide policy makers in improving the health of an individual and their environment, it is important to identify the social factors that predispose individuals to poor and dangerous environments as well as environmental factors that must be changed. The aim of this study is to analyze social determinants of health indicators and its association with communicable, non-communicable, and injury-related DALYs and deaths.

The rationale for the conduct of the study is to elucidate the national performance of various countries in reference to the WHO's Political Declaration on Social Determinants of Health conducted in October 2011 in Rio de Janeiro, Brazil where 125 member-states agreed to implement health equity by addressing the social causes of ill-health. The social determinants of health (SDH) are the non-medical factors that affect health and health outcomes including income and social protection, education, unemployment and job insecurity, working life conditions, housing, basic amenities and the environment, among others.

The Social Determinants of Health (SDH) Approach addresses Health Equity (HE), as such SDH is also coined with HE approach. There is now a growing awareness of the importance of SDH in addressing public health policies due to health inequalities. On the other hand, although there has been an increasing trend of the adoption of SDH in public policy research, health inequalities are still evident, and may be increasing in some population groups, because this perspective has failed to reach government's policy agenda.

There is a need for health policies to specifically target the most affected groups which are likewise the most vulnerable and marginalized in society. In the absence of public policies, social groups who are suffering most from income and resource poverty, also experience more barriers in accessing healthcare, and have lesser capacity to undertake preventive measures in safeguarding their health. Where there is no public health policy approach, and all forces are left to the market, inequality arises due to the vicious cycle of poverty. Using this approach and criteria, the farmers and fishermen are eligible to be among the priority groups for a comprehensive health agenda. This document will contribute in mapping out how some contexts and mechanisms influence the health of farmers and fishermen across vulnerability dimension, and then propose a health agenda for these population groups.

Tackling the social determinants of health also leads to an investigation of the environmental, cultural, and socio-economic factors that influence the health and safety of farmers and fishermen. Unless standards for work and working conditions are made mandatory, their effectiveness to address health issues will not be realized. Where there is no legal standard, these working populations are vulnerable to adverse working conditions.

The suggested health policy approach to cover farmers/agricultural workers and fishermen should contain certain key elements such as:

1. An approach or policy that takes into consideration the social determinants of health (SDH);
2. An approach that takes into account inequalities and poverty;
3. An approach that considers risk factors and hazards at work (To maximize health benefits, it is advantageous to include health-related criteria such as suffering from a chronic condition because of exposure to hazards at work.);
4. A design that combines funding schemes and eligibility criteria based on a combination of universality (Universal Health), and measures to cover the most population with the most pressing needs;
5. Considering how culture and tradition affect the health behavior; and
6. Factoring in the fact that the way population groups cope with their health needs depends on their own resources, and resources provided by institutions.

METHODS

Social determinants of health (SDH) are non-medical factors that influence health outcomes. Here, selected data from the WHO, World Bank, and International Labor Organization (ILO) are compiled into one database. Socio-economic are used as independent variables to model health outcomes such as mortality rates, disability-adjusted life years, and deaths and injuries due to occupational injuries. Countries serve as the "respondents", thus the total sample size from the database is 194. The data collected are the latest measurement of health and socio-economic indicators for each country as of 2021 (Appendix A).

The variables selected tries to cover an aspect of each of the 17 SDH. The independent variables are selected through forward-stepwise selection. Missing values are imputed though mean imputation by country income classification (low, lower middle, upper middle, high). Data obtained from the World Bank are extracted from the World Bank Open Data website.[4] Data from WHO are extracted from WHO's Global Health Observatory website.[5] Data from the International Labor Organization are extracted from ILOSTAT.[6] Death Rate data was obtained from the Global Burden of Disease Study 2019, retrieved from the Global Health Data Exchange website.[7]

For the Upper-Middle Income Group, there are 54 countries included. Similarly, indicators with a maximum of 10% missing values (5 missing values) were included. Additionally, variables with 0 variance were dropped due to the error SPSS shows preventing factor analysis to proceed. These variables have constant values for all countries included, such as "Number of cases of poliomyelitis caused by wild poliovirus" which has a value of 0 for all countries.

Accordingly, there are 17 social determinants of health, namely: 1) Income and Income Distribution; 2) Education; 3) Unemployment and Job Security; 4) Employment and Working Conditions; 5) Early Child Development; 6) Food Insecurity; 7) Housing; 8) Social Exclusion; 9) Social Safety Net; 10) Health Services; 11) Geography; 12) Disability; 13) Indigenous Ancestry; 14) Gender; 15) Immigration; 16) Race; and 17) Globalization.

The study was registered with the Research Grants Administration Office of the University of the Philippines Manila.

RESULTS

There are several variables included in the meta-analysis such as infectious, parasitic, neonatal, and nutritional disability-adjusted life years (DALYs) attributable to the environment, non-communicable diseases disability-adjusted life years (DALYs) attributable to the environment, injuries disability-adjusted life years (DALYs) attributable to the environment, and others (Appendix B).

Infectious, Parasitic, Neonatal, and Nutritional Disability-adjusted Life Years (DALYs) and Deaths Attributable to the Environment

The overall regression in Table 1 is statistically significant (R^2 = 0.789, F(7, 186) = 99.12, p <0.0001), of which 78.9% of the dependent variable is accounted for by the model. For every 10 person increase in adult illiterate population (+15 years) there is an increase in the average of infectious, parasitic, neonatal, and nutritional DALYs by 1.76 years. For every 1% increase in the population deprived of drinking water, there is an increase in the average infectious, parasitic, neonatal, and nutritional (IPNN) DALYs attributable to the environment by 49382.540 years. For every 1 microgram per cubic meter increase in average rural concentrations of fine particulate matter, there is an increase in IPNN DALYs attributable to the environment by 34627.631 years. A 1% increase in the proportion of youth (aged 15-24 years) not in education, employment, or training (NEET) is associated with a decrease in IPNN DALYs attributable to the environment by 38700.426 years. For every 1% increase in the proportion of population with monetary poverty, there is an increase of IPNN DALYs attributable to the environment by 30429.321 years. A 1% increase in the adult literacy rate (15+ years) is associated with an increase in IPNN DALYs attributable to the environment by 0.176.

The overall regression in Table 2 is statistically significant (R^2 = 0.837, F(6, 187) = 159.46, p <0.0001), of which 83.7% of the dependent variable accounted for by the model. Holding all variables at zero, the average IPNN deaths attributable to the environment is 4604.382 deaths. For every 1 person increase in the adult illiterate population (15+ years), there is an increase in IPNN deaths by 0.003. For every 1% increase in the population deprived of monetary poverty, there is an increase IPNN deaths by 315.943. For every 1 microgram per cubic meter increase in average rural concentration of fine particulate matter, there is an increase of IPNN deaths by 345.218. For every 1% increase in the proportion of youth NEET, there is a decrease in IPNN deaths by 425.501. An increase of 1000 in the non-agriculture informal employment is associated with a decrease in the IPNN deaths by 362.367. For every 1% increase in the proportion of the population deprived of drinking water, there is an increase in IPNN deaths by 498.636.

Non-communicable Diseases Disability-adjusted Life Years (DALYs) and Deaths Attributable to the Environment

The overall regression in Table 3 is statistically significant (R^2 = 0.614, F(7, 186) = 42.28, p <0.0001), of which 61.4%

Table 1. Linear Regression of Infectious, Parasitic, Neonatal, and Nutritional Disability-Adjusted Life Years (DALYs) Attributable to the Environment and Certain Social Determinants of Health

Independent Variables	Parameter Estimate	Std. Error	*p*-value	95% CI for Parameter Estimate	
				Lower Bound	Upper Bound
(Constant)	-2107158.0	1382784.6	.129	-4835115.681	620799.621
Adult illiterate population, 15+ years, both sexes (number)	0.2	7.0E-03	.000	-4835115.7	620799.6
Multidimensional poverty, Drinking water (% of population deprived)	49382.5	18058.1	.007	0.2	0.2
Rural (Average) Concentrations of fine particulate matter ($PM_{2.5}$)	34627.6	9687.5	.000	13757.5	85007.6
Proportion of youth (aged 15-24 years) not in education, employment or training (%)	-38700.4	14116.5	.007	15516.2	53739.1
Total Informal employment (thousands)	-19850.7	11050.9	.074	-66549.5	-10851.4
Multidimensional poverty, Monetary poverty (% of population deprived)	30429.3	11959.7	.012	-41651.9	1950.6
Adult literacy rate, population 15+ years, both sexes (%)	25154.5	11759.3	.034	6835.3	54023.4

of the dependent variable accounted for by the model. For every 1 million increases in the number of poor living at $3.10 a day, there is an increase in NCD DALYs attributable to the environment by 153921.991 years. A 1000 increase in the agriculture employment outside the formal sector is associated with a decrease in NCD DALYs attributable to the environment by 1077.650 years. For every 1 person increase in the adult illiterate population (15+ years), there is an increase of NCD DALYs attributable to the environment by 0.219 years. For every 1 thousand increases in the non-agricultural informal employment, there is an increase in NCD DALYs by 369.123 years. A 1% increase in the proportion of the population covered by at least one social protection benefit is associated with an increase in NCD DALYs attributable to the environment by 120543.843 years. For every 1% increase in vulnerable persons covered by social assistance there is a decrease in NCD DALYs by 79501.131 years. For every $1 increase in the median daily per capita income or consumption expenditure, there is a decrease in NCD DALYs attributable to the environment by 75568.882 years.

The overall regression in Table 4 is statistically significant ($R^2 = 0.495, F(5, 188) = 36.88, p < 0.0001$), of which 49.5% of the dependent variables accounted for the model. For every 1,000,000 increase in the number of poor living with 3.10 dollars a day, there is an increase in NCD deaths attributable to the environment by 4600.007. A 1000 increase in agriculture employment outside the formal sector is associated with a decrease in NCD deaths attributable to the environment by 35.606. For every 1 person increase in the adult illiterate population (15+ years), there is an increase in NCD deaths attributable to the environment by 0.008. For every 1000 increase in the non-agriculture informal employment, there is an increase in NCD deaths attributable to the environment by 11.743. A 1% increase in the proportion of the population of people above the retirement age receiving pension is associated with an increase in NCD deaths by 1206.648.

Injuries Disability-adjusted Life Years (DALYs) and Deaths Attributable to the Environment

The overall regression in Table 5 was statistically significant ($R^2 = 0.821, F(9, 184) = 94.09, p < 0.0001$), of which 82.1% of the dependent variable accounted for the model. For every 1 person increase in adult illiterate population (15+ years), injuries DALYs increases by 0.092 years. For every 1 person increase in the number of poor living at 3.10 dollars a day, there is an increase in injuries DALY by 42244.771 years. An increase of 1,000 persons employed in agriculture outside the formal sector is associated with a decrease in injuries DALYs by 281.058 years. For every 1000 increase in non-agriculture informal employment, there is an increase in injuries DALYs by 99.693 years. For every $1 increase in the median daily per capita income or consumption expenditure,

Table 2. Linear Regression of Infectious, Parasitic, Neonatal, and Nutritional Deaths Attributable to the Environment and Social Determinants of Health

Independent Variables	Parameter Estimate	Std. Error	*p*-value	95% CI for Parameter Estimate	
				Lower Bound	Upper Bound
(Constant)	4604.4	6624.9	.488	-8464.8	17673.5
Adult illiterate population, 15+ years, both sexes (number)	3.0E-03	0.0E+00	.000	0.0	0.0
Multidimensional poverty, Monetary poverty (% of population deprived)	315.9	140.0	.025	39.7	592.2
Rural (Average) Concentrations of fine particulate matter ($PM_{2.5}$)	345.2	115.0	.003	118.4	572.0
Proportion of youth (aged 15-24 years) not in education, employment or training (%)	-425.5	169.1	.013	-759.2	-91.8
Non-agriculture Informal employment (thousands)	-362.4	134.8	.008	-628.2	-96.5
Multidimensional poverty, Drinking water (% of population deprived)	498.6	215.9	.022	72.7	924.5

Table 3. Linear Regression of Non-communicable Diseases Disability-Adjusted Life Years (DALYs) Attributable to the Environment and Social Determinants of Health

Independent Variables	Parameter Estimate	Std. Error	*p*-value	95% CI for Parameter Estimate	
				Lower Bound	Upper Bound
(Constant)	-2307657.7	975419.4	.019	-4231965.3	-383350.2
Number of poor at $3.10 a day (2011 PPP) (millions)	153922.0	26989.5	.000	100677.0	207167.0
Agriculture Employment outside the formal sector (thousands)	-1077.7	200.8	.000	-1473.8	-681.5
Adult illiterate population, 15+ years, both sexes (number)	0.2	0.1	.001	0.1	0.3
Non-agriculture Informal employment (thousands)	369.1	109.7	.001	152.7	585.6
Population covered by at least one social protection benefit	120543.8	30203.0	.000	60959.4	180128.3
Vulnerable persons covered by social assistance	-79501.1	30930.8	.011	-140521.5	-18480.8
Median daily per capita income or consumption expenditure (2011 PPP)	-75568.9	30990.7	.016	-136707.3	-14430.4

there is a decrease in injuries DALYs by 25870.781 years. A 1% increase in the proportion of the population covered by at least one social protection benefit is associated with an increase in injuries DALYs by 28610.044 years. For every 1% increase in the proportion of vulnerable persons covered by social assistance, injuries DALYs decreased by 20601.296 years. A 1% increase in proportion of youth not in education, employment or training (NEET) is associated with a decrease in injuries DALYs by 21565.397 years. For every increase of 1 microgram per cubic meter in total average concentrations of fine particulate matter, there is an increase in injuries DALYs by 10987.533 years.

The overall regression in Table 6 was statistically significant (R^2 = 0.807, F(8, 185) = 96.74, p <0.0001), of which 80.7% of the dependent variables accounted for the model. For every 1 person increase in the adult illiterate population (15+ years), there is an increase in injury deaths attributable to the environment by 0.002. A 1,000,000 increase in the number of poor living with 3.10 dollars a day is associated with an increase in injury deaths attributable to the environment by 799.161. A 1000 person increase in the agriculture employment outside the formal sector is associated with a decrease in injury deaths attributable to the environment by 4.814. For every 1000 increase in the non-agriculture informal employment, there is an increase in injury deaths attributable to the environment by 1.587. A 1% increase in the proportion of the population covered by at least one social protection benefit is associated with an increase in injury deaths attributable to the environment by 521.547. For every $1 increase in the median daily per capita income, there is a decrease in injury deaths attributable to the environment by 495.408. For every 1% increase in the proportion of vulnerable persons covered by social assistance, there is a decrease in injury deaths attributable to the environment by 374.372. A 1% increase in the proportion of youth not in education, employment or training (NEET) is associated with a decrease in injury deaths attributable to the environment by 325.348.

DISCUSSION

Infectious, Parasitic, Neonatal, and Nutritional Disability-adjusted Life Years (DALYs) and Deaths Attributable to the Environment

Infectious, parasitic, neonatal, and nutrition-related diseases are more common in low and middle income countries (LMICs) and comprise their top 10 causes of death as compared to higher income countries.[8] This is because

Table 4. Linear Regression of Non-communicable Diseases Deaths Attributable to the Environment and Social Determinants of Health

Independent Variables	Parameter Estimate	Std. Error	*p*-value	95% CI for Parameter Estimate	
				Lower Bound	Upper Bound
(Constant)	-79718.2	28492.7	.006	-135924.6	-23511.8
Number of poor at $3.10 a day (2011 PPP) (millions)	4600.0	1004.2	.000	2619.0	6581.0
Agriculture Employment outside the formal sector (thousands)	-35.6	7.4	.000	-50.3	-20.9
Adult illiterate population, 15+ years, both sexes (number)	0.0	0.0	.001	0.0	0.0
Non-agriculture Informal employment (thousands)	11.7	4.1	.005	3.7	19.8
Persons above retirement age receiving a pension	1206.6	436.6	.006	345.4	2067.9

Table 5. Linear Regression of Injuries Disability-Adjusted Life Years (DALYs) Attributable to the Environment and Social Determinants of Health

Independent Variables	Parameter Estimate	Std. Error	*p*-value	95% CI for Parameter Estimate	
				Lower Bound	Upper Bound
(Constant)	-183509.3	375081.7	.625	-923523.2	556504.5
Adult illiterate population, 15+ years, both sexes (number)	0.1	0.0	.000	0.1	0.1
Number of poor at $3.10 a day (2011 PPP) (millions)	42244.8	6661.7	.000	29101.7	55387.9
Agriculture Employment outside the formal sector (thousands)	-281.1	49.2	.000	-378.2	-183.9
Non-agriculture Informal employment (thousands)	99.7	26.7	.000	46.9	152.5
Median daily per capita income or consumption expenditure (2011 PPP)	-25870.8	7851.6	.001	-41361.6	-10380.0
Population covered by at least one social protection benefit	28610.0	7379.3	.000	14051.0	43169.0
Vulnerable persons covered by social assistance	-20601.3	7540.0	.007	-35477.2	-5725.3
Proportion of youth (aged 15-24 years) not in education, employment or training (%)	-21565.4	8557.9	.013	-38449.6	-4681.2
Total (Average) Concentrations of fine particulate matter ($PM_{2.5}$)	10987.5	4968.4	.028	1185.2	20789.9

Table 6. Linear Regression of Injuries Deaths Attributable to the Environment and Social Determinants of Health

Independent Variables	Parameter Estimate	Std. Error	*p*-value	95% CI for Parameter Estimate	
				Lower Bound	Upper Bound
(Constant)	135.7	6246.5	.983	-12187.8	12459.2
Adult illiterate population, 15+ years, both sexes (number)	0.0	0.0	.000	0.0	0.0
Number of poor at $3.10 a day (2011 PPP) (millions)	799.2	122.3	.000	557.8	1040.5
Agriculture Employment outside the formal sector (thousands)	-4.8	0.9	.000	-6.6	-3.0
Non-agriculture Informal employment (thousands)	1.6	0.5	.001	0.6	2.6
Population covered by at least one social protection benefit	521.5	135.4	.000	254.3	788.8
Median daily per capita income or consumption expenditure (2011 PPP)	-495.4	143.0	.001	-777.5	-213.3
Vulnerable persons covered by social assistance	-374.4	138.7	.008	-648.0	-100.7
Proportion of youth (aged 15-24 years) not in education, employment or training (%)	-325.3	157.3	.040	-635.6	-15.1

LMICs are more likely to have less access to clean water and sanitation facilities and placing them at risk to various infectious and waterborne diseases.[9,10] This is consistent with the analysis of this SDH study where an increase in the population deprived of drinking water led to the largest increase of IPNN DALYs and deaths attributable to the environment compared to the other significant variables. Other poverty indicators such as monetary poverty also showed that an increase in this indicator lead to an increase in IPNN DALYs. Poverty and health share a circular relationship where impoverished situations lead to poor health and poor health can lead to impoverished situations. Aside from affecting an individual's capacity to afford better housing, it also affects their capacity to access and afford quality healthcare.[10] Such is the case for neonatal mortality and diseases which remain to be a significant health concern in areas with lacking healthcare facilities.[11]

This study observed that adult illiteracy led to an increase in IPNN DALYs and deaths. This is consistent in other studies which found health literacy, adult literacy, and education are mediating factors[12-14] to prevent poor health outcomes and poor health decisions[15]. In the study of Castro-Sanchez et al.,[15] they observed that health literacy was important in encouraging proper use of antibiotics, having vaccination for vaccine-preventable diseases, and practicing safe sex. On the other hand, Gupta et al.),[12] observed a positive association between health literacy and health status, which also included the prevention of foodborne diseases.

Fine particulate matter is also known to have the capacity to bring with it biological pathogens that may cause infection and disease among exposed individuals.[16] In Bangladesh, an increase in $PM_{2.5}$ concentrations was found to increase the incidences of pneumonia among children.[17] During the pandemic, various studies have also observed an increase in COVID-19 cases whenever $PM_{2.5}$ concentrations increased as well.[18-20] However, $PM_{2.5}$ does not only contribute to the spread of disease but also subjects the respiratory system to inflammation and injury. This increases the host's susceptibility to developing infections.[19] This is important to note as rural average concentration of fine particulate matter were found in this SDH study to increase the number of IPNN DALYs and deaths attributable to the environment. Moreover, infectious disease mortality and severity tend to increase with age and reach a steep rise towards the older age group. Before this, only the infancy period shows a significantly high rise in infectious disease severity compared to other age groups.[21] A similar trend is observed in an age-period-cohort analysis among residents in China. Additionally, it was observed that infectious disease mortality was at the lowest during the ages 10 to 19 years.[22] This may explain the associated reduction of IPNN DALYs and deaths with every increase of proportion of youth NEET.

Non-communicable Diseases Disability-adjusted Life Years (DALYs) and Deaths Attributable to the Environment

Non-communicable disease is a growing health concern across the globe which comprises 60% of all deaths. Moreover, majority of these deaths (80%) occur in LMICs. It is clear that NCD prevalence does not only occur due to biological reasons but affected by social, economic, and political reasons as well. However, policies to address this problem have been confined merely within the health sector, excluding non-health sectors.[23] In this SDH study, there is an observed association of various socioeconomic factors and NCD deaths and DALYs attributable to the environment.

Among the variables studied, four major socioeconomic factors are associated. These ware income, education (literacy), employment, and social welfare programs. The number of poor living with 3.10 dollars a day increased NCD DALYs and deaths attributable to the environment. An increase in median daily per capita income also resulted in a decrease in NCD DALYs attributable to the environment. For common NCDs affecting individuals globally, in a systematic review, Williams et al.[24] observed that cancer and cardiovascular diseases are associated with lower socioeconomic status, such as income, literacy, and access to basic needs. On the other hand, those with higher socioeconomic status are more likely

to have diabetes.[24] Those from lower socioeconomic status are also more likely to engage in unhealthy behaviors which serve as risk factors for non-communicable diseases. These risk factors are found to be alcohol consumption, tobacco smoking, consumption of less fiber and fish.[25] Moreover, individuals with lower socioeconomic status and educational attainment are also more likely to be alcoholic consumers and tobacco smokers.[26] Among cancer incidences, more cases are observed among countries with higher sustainable development index, however majority of deaths and mortality where among countries with lower measures. During the year 2017, cancers that comprised the top 10 were nonmelanoma skin cancer, lung cancers and associated structures, breast cancer, colon and rectum cancer, prostate cancer, stomach cancer, liver cancer, cervical cancer, non-Hodgkin lymphoma, and bladder cancer.[27] Moreover, households in LMICs with members diagnosed with NCDs are burdened with a cost reaching thousands of dollars annually.[28] Therefore, low socioeconomic status not only predisposes an individual to develop NCDs but also determines their capacity to cope and manage the illness.

Informal work may also predispose an individual to developing NCDs. A study among Thai informal workers observed that agricultural workers, unskilled workers, services, and sales workers were more likely to have NCDs (i.e. hypertension, stroke, ischemic heart disease, thyroid gland disorders).[29] In another study by Madero-Cabib et al.,[30] formal employment even with occasional engagement in NCD risk factors such as alcohol consumption, was seen as protective against certain NCDs. This was compared to lifetime informal employment which was only protective if the individual did not smoke or consume alcohol. However, it was clear that employment played a significant role in preventing the occurrence of NCDs. Absence of social health coverage was associated with informal employment and the development of poor health.[31] This is consistent with the finding in this SDH study that an increase in vulnerable persons covered by social assistance reduced NCD DALYs. An increase in persons above retiring age receiving pension was also found to decrease NCD deaths attributable to the environment. Supposedly, social assistance programs improve health by reducing poverty and inequality.[32] However, evaluation of practical applications of social protection and assistance programs show that these have not been successful in improving health.[33,34] This may also have been influenced by the initial poor health and low socioeconomic status of those receiving these benefits and the inadequacy of the benefit given to protect them from income insecurity.[34,35] Hence, rather than the presence of a social protection benefit, it is more important to look into the specific types of social benefits that improve health among its recipients.

Interestingly, NCD DALYs and deaths both decreased when agricultural employment outside the formal sector increased. This is consistent with other studies where cardiovascular diseases were found to be less prevalent among agricultural workers. The reduction observed may be due to the relatively high occupation physical activity associated with agricultural work. In the study of Du et al.,[36] among Chinese farmers, agricultural farmers who did not experience any change in their occupation or had seasonal changes in their occupation were less likely to develop dyslipidemia. Another study among workers in rural Australia also observed that among the occupations studied, those employed in the agricultural sector had lower cardiovascular risk due to higher occupation activity, and healthier diets.[37]

Injuries Disability-adjusted Life Years (DALYs) and Deaths Attributable to the Environment

According to the WHO,[8] death from injuries is often caused by road traffic crashes, suicide, homicide, and war or conflict. For those falling within the ages of 10-49 years, road traffic injuries are among the top 10 causes of DALYs. Moreover, lower income countries experience an increase in DALYs, while the opposite was true for higher income countries.[38] This, again, highlighted the disparity in injury prevalence and severity among countries with varying income and development status. In this SDH study, an increase in the number of poor living at 3.10 dollars a day led to an increase in injury DALYs and deaths; while, an increase in the medial daily per capita income led to a decrease in injury DALYs and deaths. Neighborhood socioeconomic status, and not just individual socioeconomic status, was also observed to be associated with injury incidence. Such that those from lower neighborhood socioeconomic status, were more likely to have higher incidences of injuries.[39-41] Although, the study of Zarzaur et al.[42] observed that motorcycle crashes are higher in high- and low-income neighborhoods, while low-income neighborhood also reported higher assault rates.

Employment indicators are also found in this SDH study to be associated with injury DALYs and deaths. Agricultural employment outside the formal sector proportion of youth NEET reduced injury DALYs and deaths; while, non-agriculture informal employment increased injury DALYs and deaths. The former observation may be due to underreporting of injuries as studies have been clear that injuries are high amongst the young adults[38] and agricultural sector.[43] Underreporting is highly possible as youth not enrolled into any activities make it difficult to gather data on their health status. Similar difficulty is also observed for those informally employed in the agricultural sector.[44,45] Lesser-known injuries, such as cuts and blunt-object injuries, are more likely to occur from agriculture-related activities.[46] Generally, the informal sector is associated with higher risks and hazards that limit occupational safety in the workplace.[47] Occupational injuries are also more likely to be experienced by those from lower income levels.[48] Moreover, individuals employed in the informal sector were less likely to seek medical care for their injuries, further subjecting them to poor health and worsening injury.[49] This is consistent as well with the analysis of this SDH study where if more vulnerable persons were covered

by social assistance, there would be a reduction in injuries DALYs and deaths. However, the analysis also noted that despite an increase in population covered by at least one social protection benefit, there was an increase in injury DALYs and deaths. As previously mentioned, the benefit of social welfare programs are dependent on its delivery and adequacy. It is not uncommon for a population, especially those from lower incomes, to be covered by an insurance policy, yet still be unable to receive the care needed due to underinsurance.[50]

In addition to the previously discussed socioeconomic factors, the analysis of this SDH study found that an increase in total average concentrations of fine particulate matter led to an increase in injuries DALYs. It is unclear how fine particulate matter may directly cause injury, however, it may reflect road traffic conditions. This is because an increase in traffic, especially among developing countries, result in higher concentrations of air pollutants.[51] Moreover, a study by Sager[52] observed that for every 1 ug/m^3 increase in $PM_{2.5}$, there was also an increase in road crashes which was attributed to the effect of air pollution on impairing cognition. This is consistent with other studies that found traffic-related fine particulate matter and its capacity to impair cognitive structures.[53,54]

The individual's environment plays an especially significant role in causing injuries. It suggests that injury occurs due to the interaction between the host/victim, agent/offending agent, and environment (i.e., physical, social). This interaction of factors is always present in the different phases of injury occurrence which are the pre-event, event, and post-event. All of these play a role in determining the capacity to prevent, respond or protect, and recover from injury severity.[55]

The study used the databases of WHO, ILO, and WB, however, not all countries are present in all three databases. This serves as a limitation. For some missing data, average values based on country's income class were imputed for analysis. The income class was used to minimize bias.

CONCLUSION

This study has shown the role of socioeconomic factors in causing morbidity, disability, and mortality. Income, employment, education, and social welfare program indicators have consistently been shown to be associated with disability-adjusted life years and deaths for communicable and non-communicable diseases, and injuries. This analysis further supports and adds to the knowledge on socioeconomic and environmental indicators that affect the health of people. However, it also shows that there is a need to further analyze specific socioeconomic indicators and identify those that affect health. Further research is needed to standardize indicators that will assist governments and institutions in screening for risk factors that may subject an individual to poor health outcomes subsequently translating into DALYs and deaths for nations.

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Statement of Authorship

Both authors certified fulfillment of ICMJE authorship criteria.

Author Disclosure

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APPENDICES

Appendix A. Variables Considered in the Analysis

Variables	Data Source
Infectious, parasitic, neonatal, and nutritional Disability-adjusted life years (DALYs) attributable to the environment*	World Health Organization
Non-communicable diseases Disability-adjusted life years (DALYs) attributable to the environment*	World Health Organization
Injuries Disability-adjusted life years (DALYs) attributable to the environment*	World Health Organization
Infectious, parasitic, neonatal, and nutritional Deaths attributable to the environment*	World Health Organization
Non-communicable diseases Deaths attributable to the environment*	World Health Organization
Injuries Deaths attributable to the environment*	World Health Organization
Adult illiterate population, 15+ years, both sexes (number)	World Bank
Adult illiterate population, 15+ years, female (number)	World Bank
Adult illiterate population, 15+ years, male (number)	World Bank
Adult literacy rate, population 15+ years, both sexes (%)	World Bank
Gini index (World Bank estimate)	World Bank
Median daily per capita income or consumption expenditure (2011 PPP)	World Bank
Multidimensional poverty, Drinking water (% of population deprived)	World Bank
Multidimensional poverty, Educational attainment (% of population deprived)	World Bank
Multidimensional poverty, Educational enrollment (% of population deprived)	World Bank
Multidimensional poverty, Electricity (% of population deprived)	World Bank
Multidimensional poverty, Headcount ratio (% of population)	World Bank
Multidimensional poverty, Monetary poverty (% of population deprived)	World Bank
Multidimensional poverty, Sanitation (% of population deprived)	World Bank
Number of poor at $3.10 a day (2011 PPP) (millions)	World Bank
Access to clean fuels and technologies for cooking (% of population)	World Bank
Access to electricity (% of population)	World Bank
Adjusted net national income (annual % growth)	World Bank
Adjusted net national income per capita (annual % growth)	World Bank
CPIA gender equality rating (1=low to 6=high)	World Bank
Rural population	World Bank
Rural population (% of total population)	World Bank
Strength of legal rights index (0=weak to 12=strong)	World Bank
Surface area (sq. km)	World Bank
Unemployment, total (% of total labor force) (modeled ILO estimate)	World Bank
Urban population	World Bank
Urban population (% of total population)	World Bank
Vulnerable employment, total (% of total employment) (modeled ILO estimate)	World Bank
Population covered by at least one social protection benefit	International Labor Organization
Persons above retirement age receiving a pension	International Labor Organization
Unemployed receiving unemployment benefits	International Labor Organization
Poor persons covered by social protection systems	International Labor Organization
Vulnerable persons covered by social assistance	International Labor Organization
Proportion of youth (aged 15-24 years) not in education, employment or training (%)	International Labor Organization
Total U.S. dollars Average monthly earnings of employees	International Labor Organization
Total Informal employment (thousands)	International Labor Organization
Agriculture Informal employment (thousands)	International Labor Organization
Non-agriculture Informal employment (thousands)	International Labor Organization
Total Employment outside the formal sector (thousands)	International Labor Organization

Appendix A. Variables Considered in the Analysis *(continued)*

Variables	Data Source
Agriculture Employment outside the formal sector (thousands)	International Labor Organization
Non-agriculture Employment outside the formal sector (thousands)	International Labor Organization
Agriculture Informal employment (thousands)	International Labor Organization
Non-agriculture Informal employment (thousands)	International Labor Organization
Total (Average) Concentrations of fine particulate matter ($PM_{2.5}$)	World Health Organization
Urban (Average) Concentrations of fine particulate matter ($PM_{2.5}$)	World Health Organization
Rural (Average) Concentrations of fine particulate matter ($PM_{2.5}$)	World Health Organization
General government expenditure on health as a percentage of total government expenditure	World Health Organization
Food Safety Level C4	World Health Organization
Density of medical doctors (per 10,000 population)	World Health Organization
Density of nursing and midwifery personnel (per 10,000 population)	World Health Organization
Density of dentists (per 10,000 population)	World Health Organization
Density of pharmacists (per 10,000 population)	World Health Organization

**Dependent Variable*

Appendix B. Mean and Standard Deviation of Variables Considered in the Analysis

Variables	Mean	Std. Deviation
Infectious, parasitic, neonatal, and nutritional Disability-adjusted life years (DALYs) attributable to the environment*	1039802.7	3994586.6
Non-communicable diseases Disability-adjusted life years (DALYs) attributable to the environment*	1423836.6	6853883.9
Injuries Disability-adjusted life years (DALYs) attributable to the environment*	610650.2	2440346.5
Infectious, parasitic, neonatal, and nutritional Deaths attributable to the environment*	12905.6	54682.1
Non-communicable diseases Deaths attributable to the environment*	42117.2	227111.5
Injuries Deaths attributable to the environment*	10052.0	43307.7
Adult illiterate population, 15+ years, both sexes (number)	5812497.0	18985003.5
Adult illiterate population, 15+ years, female (number)	3666168.7	12215061.0
Adult illiterate population, 15+ years, male (number)	2146328.2	6791660.3
Adult literacy rate, population 15+ years, both sexes (%)	83.0	14.8
Gini index (World Bank estimate)	38.1	7.4
Median daily per capita income or consumption expenditure (2011 PPP)	21.5	11.1
Multidimensional poverty, Drinking water (% of population deprived)	11.5	11.9
Multidimensional poverty, Educational attainment (% of population deprived)	14.0	15.4
Multidimensional poverty, Educational enrollment (% of population deprived)	10.2	9.2
Multidimensional poverty, Electricity (% of population deprived)	18.3	23.3
Multidimensional poverty, Headcount ratio (% of population)	19.2	22.3
Multidimensional poverty, Monetary poverty (% of population deprived)	13.4	17.5
Multidimensional poverty, Sanitation (% of population deprived)	26.8	24.4
Number of poor at $3.10 a day (2011 PPP) (millions)	17.8	53.4
Access to clean fuels and technologies for cooking (% of population)	67.5	37.2
Access to electricity (% of population)	85.4	24.4
Adjusted net national income (annual % growth)	5.5	25.8
Adjusted net national income per capita (annual % growth)	4.1	25.4
CPIA gender equality rating (1=low to 6=high)	3.4	0.5
Rural population	17685477.4	76876889.0
Rural population (% of total population)	40.5	22.8
Strength of legal rights index (0=weak to 12=strong)	5.6	3.1
Surface area (sq. km)	698163.7	1917822.5

Appendix B. Mean and Standard Deviation of Variables Considered in the Analysis *(continued)*

Variables	Mean	Std. Deviation
Unemployment, total (% of total labor force) (modeled ILO estimate)	8.4	5.7
Urban population	22521076.7	76533884.6
Urban population (% of total population)	59.5	22.8
Vulnerable employment, total (% of total employment) (modeled ILO estimate)	38.4	26.2
Population covered by at least one social protection benefit	54.7	24.5
Persons above retirement age receiving a pension	55.4	27.4
Unemployed receiving unemployment benefits	17.2	15.2
Poor persons covered by social protection systems	73.9	17.0
Vulnerable persons covered by social assistance	39.5	24.0
Proportion of youth (aged 15-24 years) not in education, employment or training (%)	20.1	9.7
Total U.S. dollars Average monthly earnings of employees	2376.4	9512.0
Total Informal employment (thousands)	10983.5	24366.2
Agriculture Informal employment (thousands)	4688.2	11524.6
Non-agriculture Informal employment (thousands)	6295.3	12993.0
Total Employment outside the formal sector (thousands)	8781.7	21129.7
Agriculture Employment outside the formal sector (thousands)	4114.4	11111.8
Non-agriculture Employment outside the formal sector (thousands)	4667.3	10079.0
Agriculture Informal employment (thousands)	69.5	17.4
Non-agriculture Informal employment (thousands)	44.3	13.7
Total (Average) Concentrations of fine particulate matter ($PM_{2.5}$)	24.8	16.4
Urban (Average) Concentrations of fine particulate matter ($PM_{2.5}$)	25.4	16.7
Rural (Average) Concentrations of fine particulate matter ($PM_{2.5}$)	23.8	15.7
General government expenditure on health as a percentage of total government expenditure	11.7	4.9
Food Safety Level C4	64.7	25.3
Density of medical doctors (per 10,000 population)	18.6	16.7
Density of nursing and midwifery personnel (per 10,000 population)	44.5	42.9
Density of dentists (per 10,000 population)	3.6	3.7
Density of pharmacists (per 10,000 population)	4.1	4.1

**Dependent Variable*