Original Research

SAGE Open
April-June 2019: 1–8
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DOI: 10.1177/2158244019854496
journals.sagepub.com/home/sgo
SAGE

National Level Social Determinants of Health and Outcomes: Longitudinal Analysis of 27 Industrialized Countries

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Abstract

To improve health, it is important to understand the social determinants of health (SDH). This study aimed to identify the SDH through national-level indices in industrialized countries. To examine the SDH, we conducted a longitudinal analysis using a panel regression. We sampled from 27 Organisation for Economic Co-operation and Development (OECD) member countries. We chose 19 indices across four categories of health outcomes, which are the socioeconomic environment, the physical environment, health behavior, and health services. Japan ranked in the highest tier for all outcome categories, followed by Iceland, Sweden, and Switzerland. Gross domestic product (GDP, per capita), unemployment, nitrogen oxides (NO_X, kilograms per capita), tobacco consumption (SMO, grams per capita [15+]), sugar intake, fat intake, and number of doctors (DOC, per 1,000) had statistically significant effects on life expectancy at birth. GDP, NO_X, alcohol consumption, SMO, DOC, total health expenditure (THE, GDP percent), and vaccination coverage for measles (VACCINE, percent) were associated with mortality. In the case of potential years of life lost (PYLL), GDP, NO_X, alcohol consumption (ALC, liters per capita [15+]), SMO, DOC, THE, and VACCINE were statistically significant. GDP, school life expectancy, wastewater treatment rate, and VACCINE were associated with the infant mortality rate (IMR). Combining all of the results shows that to improve national-level health outcomes, tobacco and alcohol controls and nutritional policies should be strengthened first, as they will contribute more to mortality and PYLL. Vaccinations will contribute more to IMR and PYLL reductions.

Keywords

determinants of health, life expectancy, mortality, IMR, potential years of life lost, OECD

Introduction

People naturally attempt to be healthy. Historically, human beings have made many attempts and have exerted substantial effort to improve their health. During the 20th century, civilization and science achieved the greatest level of development in human history and levels of health improved considerably. Worldwide, average life expectancy increased by approximately 25 years, from 46.5 years in the 1950s to 71 years in 2013 (World Health Organization [WHO], 2017a), and the infant mortality rate (IMR) decreased from 152 to 47 deaths per 1,000 infants from the 1950s to the late 2000s (United Nations [UN], 2013). Meanwhile, continuous global efforts have been made to guarantee the right to health, to the extent that three of the eight Millennium Development Goals, which were declared by representatives of 189 countries at the UN General Assembly in September 2000 to achieve the balanced development of all human beings, were related to health.

To improve health, it is important to understand its influential factors, and diverse efforts have been made to examine these factors, known as the "determinants of health." In 1974, Marc Lalonde, the Canadian health minister at the time, produced a report describing the concept of the "health field" and suggested four important factors influencing health: human biology, environment, lifestyle, and health care organization. This model was one of the first to include systematically organized determinants of health. The social determinants of health (SDH) are defined as the conditions, such as everyday environments and personal habits, that surround an individual throughout his life, excluding biological factors determined at or prior to birth. Research has been conducted continuously to systematize and study SDH, and

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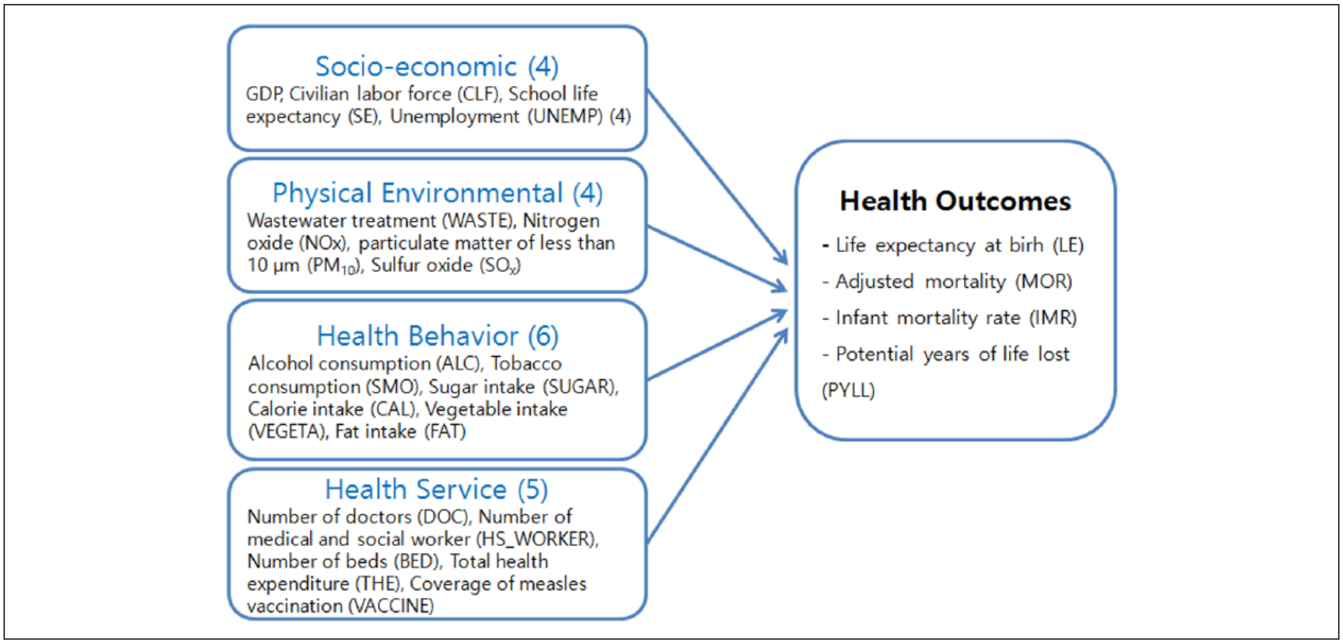

Figure 1. The structure of the social determinants of health.
Note. GDP = gross domestic product per capita.

the WHO established the Commission on Social Determinants of Health (CSDH) in March 2005 to collaboratively address poor health and health equality, which are aspects of SDH (WHO, 2017c).

Understanding previous and current levels of health and identifying the influential determinants of health are the most fundamental policies involved in health improvement (Marmot, Friel, Bell, Houweling, & Taylor, 2008). Therefore, this study aimed to identify SDH through national-level indices in industrialized countries using Organisation for Economic Co-operation and Development (OECD) data. To examine SDH, we conducted a longitudinal analysis.

Method

Study Population and Data

The subjects were 34 countries that were OECD members in April 2016. In the analysis of health determinants, we used data collected from the "OECD.Stat" website between 1994 and 2012. Data from 27 countries were analyzed, as Chile, Spain, New Zealand, Mexico, Greece, and Portugal were excluded because of missing data for the year and other variables. In principle, we used the OECD's statistics supplemented with data provided by the WHO and the Gallup World Poll. Data from 2012 were used as the baseline and missing values were imputed. Missing values can be imputed using simple or multiple imputations, and the latter method is more effective than the former, which underestimates variance (Van Buuren, 2007). Several types of multiple imputations exist; of these, the SAS PROC MI statement in the SAS statistical program is generally used in fixed-effect analysis and was used to handle missing values in this study.

Theoretical Model

To examine the determinants of health in this study, we chose 19 indices across four areas, including the socioeconomic environment, the physical environment, health behavior, and health services, and we excluded genetic factors, for which measurement and the development of interventions are difficult (Dahlgren & Whitehead, 1991; Hancock, 1986; Peppard, Kindig, Jovaag, Dranger, & Remington, 2004; Van Buuren, 2007). The study model in Figure 1 shows each explanatory variable included in the study to improve our understanding of the influence of these four areas on each health outcome. In this study, we chose life expectancy at birth (LE), age-standardized deaths per 100,000 people (mortality rate [MOR]), the IMR, and potential years of life lost (PYLL) as dependent health outcome variables. Longitudinal data were available for these variables, so conducting fixed-effect regressions was possible.

Socioeconomic factors. Gross domestic product per capita (GDP) in U.S. dollars is the most representative index of a country's economic power. As the primary index used to understand a country's labor force from the perspective of human resources, the civilian labor force (CLF) aims to identify the volume of effective labor supply and is referred to as the working, working-age, or economically active population. In general, a society with a strong labor force is considered productive and active, and data concerning armed forces are excluded from OECD data. School life expectancy (SE) indicates the average years of formal education that citizens receive during their lifetimes. The unemployment rate (UNEMP, percentage of unemployment [15+]), an index of the direction of the job market, reflects the proportion of the population that has been unemployed for more than 6 months.

Physical environmental factors. The supply of safe water and wastewater treatment (WASTE, percent) are closely related to health. The WASTE variable was used to reflect the rates of treatment provided by the private (individual citizens) and public sectors for all domestic sewage and wastewater. One in eight deaths is reportedly caused by exposure to polluted air (WHO, 2017b). Various materials pollute the air, and, according to the WHO, those that clearly influence health include ozone, nitrogen oxides (NO_X, kilograms per capita), sulfur oxides (SO_X, kilograms per capita), and particulate matter (PM10, less than or equal to 10 μm, kilograms per capita) (WHO, 2006).

This study included three independent variables describing air pollution. NO_X reflects the amount of nitrous oxide emissions per person (kg), PM10 reflects emissions per person of particulate matter of less than 10 μm (kg), and SO_X reflects the rate of sulfur oxide emissions per person (kg).

Health behavior factors. Smoking (tobacco consumption, grams per capita [15+] [SMO]) and alcohol (ALC, liters per capita [15+]) consumption are the most widely known health-related risk factors. Alcohol (L) and cigarette (g) consumption per person were both examined in individuals aged 15 years or older. The WHO adopted noncommunicable disease (NCD) management as an essential strategy for health improvement. Diabetes is the most prevalent NCD and is the eighth most common cause of death worldwide (WHO, 2011). Diabetes prevalence rates are high in North America and Europe and in Asian industrialized countries such as Korea and Japan (OECD, 2015). Ninety percent of diabetic patients have type 2 diabetes (Vos et al., 2013) caused by undesirable lifestyle habits. In this study, we used sugar consumption (SUGAR, per capita), calorie intake (CAL, per capita), vegetable consumption (VEGETA, per capita), and fat consumption (FAT, per capita) as independent variables, all of which are directly and indirectly related to diabetes.

Health services factors. The number of doctors per 1,000 people (DOC) was one of the variables used to measure health services and represents an essential component of human resources in medical services; the WHO suggests that there should be at least one primary medical care provider per 1,000 people in advanced countries to ensure the provision of basic medical services. Other variables used to measure health services included the total number of doctors, midwives, nurses, dentists, pharmacists, and hospital workers per 1,000 people (HS_WORKER; WHO, 2010); the number of beds per 1,000 people (BED), including those in acute, mental, and long-term care facilities, and total health expenditures (THE, GDP percent). This variable is one of the most widely used health determinants in macro analysis and reflects the ratio of THE to GDP. In addition, the measles vaccination rate (VACCINE, percent) was used to reflect vaccination coverage, which is a prototypical health service.

Statistical Analyses

Fixed-effect regression analysis was performed to examine health determinants in 27 industrialized countries. The inflation factor values were checked to assess multicollinearity in the explanatory variables. The model used for the basic analysis is shown below. The fixed-effect regression analysis was performed using the R statistical package. The model equation is as follows:

$$\begin{aligned}\text{Health outcome}&\\ \left(\text{LE, PYLL, MOR, IMR}\right) &= \alpha_i + \beta_1 \bullet \text{SocioEconomic}_{it}\\ &+ \beta_2 \bullet \text{PhysicalEnv}_{it}\\ &+ \beta_3 \bullet \text{HealthBehavior}_{it}\\ &+ \beta_4 \bullet \text{Health Care Service}_{it}\\ &+ E_{it},\end{aligned}$$

where i = countries, t = time point.

Prior to the calculation, the indices were z transformed to normalize the distribution because the scales used to measure the variables differed. This method transforms individual values to ensure that the normalized mean is 0 and the standard deviation is 1, and it can be performed via the "SAS PROC standard" statement.

Results

Descriptive Statistics of Health Outcomes

A health outcome score approaching 0 indicates that it is close to the average, whereas a score above or below 0 signifies a positive or negative change, respectively.

Japan had the best health outcomes over the past 19 years (1994-2012) based on the health outcomes selected as dependent variables in this study (i.e., LE, PYLL, MOR, and IMR), with an average score of 1.035 and a ranking in the highest tier for all outcome categories. Japan was followed by Iceland (0.854), Sweden (0.748), and Switzerland (0.670), showing that welfare-oriented countries fell into the upper tier for health outcomes. The former Soviet Union and Eastern Bloc countries had the worst overall health outcomes such as Estonia, Hungary, the Slovak Republic, Poland, and the Czech Republic (Table 1).

Table 1. Mean Score of Each Health Outcome, 1994-2012 (Ordered by Overall Score).

	Overall		LE		MOR		IMR		PYLL	
Countries	Rank	*M* (*SD*)	Rank	*M* (*SD*)	Rank	*M* (*SD*)	Rank	*M* (*SD*)	Rank	*M* (*SD*)
Japan	1	1.035 (0.300)	1	1.202 (0.396)	1	1.257 (0.303)	2	0.907 (0.372)	3	0.774 (0.181)
Iceland	2	0.854 (0.345)	3	0.879 (0.443)	8	0.524 (0.349)	1	1.159 (0.386)	1	0.854 (0.273)
Sweden	3	0.748 (0.293)	5	0.756 (0.346)	7	0.565 (0.296)	3	0.864 (0.533)	2	0.808 (0.210)
Switzerland	4	0.670 (0.392)	2	0.915 (0.494)	3	0.889 (0.489)	14	0.203 (0.199)	4	0.672 (0.382)
Italy	5	0.573 (0.455)	4	0.773 (0.455)	6	0.654 (0.449)	10	0.280 (0.829)	6	0.585 (0.346)
Australia	6	0.545 (0.438)	6	0.677 (0.505)	2	0.908 (0.550)	18	–0.010 (0.393)	5	0.607 (0.394)
Norway	7	0.533 (0.365)	8	0.533 (0.365)	10	0.378 (0.412)	5	0.694 (1.839)	8	0.558 (0.280)
France	8	0.441 (0.372)	7	0.600 (0.517)	4	0.743 (0.358)	11	0.276 (0.356)	17	0.143 (0.314)
Israel	9	0.365 (0.482)	9	0.530 (0.511)	9	0.464 (0.493)	19	–0.091 (0.334)	7	0.559 (0.319)
Luxembourg	10	0.354 (0.515)	14	0.196 (0.561)	11	0.350 (0.462)	7	0.422 (0.338)	10	0.448 (0.484)
Canada	11	0.345 (0.303)	10	0.519 (0.414)	5	0.698 (0.385)	22	–0.248 (1.138)	11	0.409 (0.243)
Finland	12	0.298 (0.393)	17	0.141 (0.481)	18	0.151 (0.477)	4	0.810 (0.537)	19	0.090 (0.277)
Netherlands	13	0.289 (0.390)	11	0.334 (0.471)	16	0.209 (0.443)	16	0.068 (0.598)	9	0.548 (0.291)
Austria	14	0.259 (0.428)	12	0.273 (0.516)	12	0.249 (0.471)	13	0.224 (0.623)	14	0.289 (0.366)
Germany	15	0.257 (0.413)	13	0.224 (0.413)	17	0.199 (0.447)	8	0.308 (0.563)	13	0.298 (0.365)
Belgium	16	0.192 (0.462)	16	0.172 (0.443)	15	0.217 (0.586)	15	0.157 (0.327)	16	0.220 (0.397)
United Kingdom	17	0.146 (0.456)	15	0.178 (0.506)	14	0.234 (0.597)	21	–0.210 (0.822)	12	0.381 (0.441)
Average	—	**0.000 (1.000)**	—	**0.000 (1.000)**	—	**0.000 (1.000)**	—	**0.000 (1.000)**	—	**0.000 (1.000)**
Ireland	18	–0.011 (0.573)	18	–0.006 (0.573)	21	–0.268 (0.711)	17	0.003 (0.684)	15	0.225 (0.343)
Denmark	19	–0.027 (0.440)	19	–0.213 (0.510)	20	–0.248 (0.483)	12	0.230 (0.363)	18	0.122 (0.413)
Slovenia	20	–0.130 (0.647)	22	–0.378 (0.680)	22	–0.413 (0.620)	6	0.488 (0.351)	21	–0.216 (0.640)
Korea	21	–0.166 (0.786)	20	–0.294 (0.941)	19	–0.174 (0.836)	20	–0.123 (1.546)	20	–0.073 (0.644)
United States	22	–0.421 (0.371)	21	–0.327 (0.338)	13	0.236 (0.575)	23	–1.050 (0.923)	23	–0.542 (0.358)
Czech Republic	23	–0.501 (0.612)	23	–0.848 (0.543)	23	–1.083 (0.632)	9	0.295 (0.679)	22	–0.366 (0.485)
Poland	24	–1.383 (0.849)	24	–1.296 (0.550)	24	–1.273 (0.728)	27	–1.592 (0.336)	25	–1.371 (0.658)
Slovak Republic	25	–1.420 (0.492)	25	–1.446 (0.407)	25	–1.614 (0.356)	26	–1.418 (0.239)	24	–1.201 (0.372)
Hungary	26	–1.840 (0.803)	26	–1.938 (0.578)	27	–1.983 (0.701)	25	–1.393 (0.342)	26	–2.045 (0.826)
Estonia	27	–2.006 (1.287)	27	–2.125 (0.955)	26	–1.867 (0.985)	24	–1.252 (0.254)	27	–2.779 (1.430)

Note. LE = life expectancy at birth; MOR = mortality rate; IMR = infant mortality rate; PYLL = potential years of life lost.

Table 2. Effect on Each Health Outcome.

	LE		MOR		IMR		PYLL	
	Coefficient	*SE*	Coefficient	*SE*	Coefficient	*SE*	Coefficient	*SE*
GDP	0.0566	0.000	–0.3056	0.000	–0.6456	0.000	–0.4011	0.000
CLF	–0.0143	0.552	0.2426	0.052	0.4066	0.128	0.2046	0.317
SE	0.0088	0.447	0.0877	0.145	–0.3882	0.003	–0.0089	0.928
UNEMP	0.0065	0.011	–0.0232	0.082	0.0211	0.458	–0.0062	0.777
WASTE	0.0029	0.356	0.0124	0.440	–0.2019	0.000	–0.0483	0.067
NO_X	–0.0133	0.002	0.0925	0.000	0.0132	0.784	0.1123	0.003
PM10	–0.0003	0.260	0.0022	0.164	–0.0027	0.415	0.0032	0.216
SO_X	0.0011	0.142	–0.0062	0.105	–0.0095	0.251	–0.0068	0.283
ALC	0.0042	0.418	0.0784	0.004	–0.0557	0.338	0.1115	0.013
SMO	–0.0086	0.001	0.0487	0.000	–0.0096	0.734	0.0447	0.039
SUGAR	0.0078	0.029	0.0225	0.225	0.0492	0.215	0.0465	0.126
CAL	–0.0180	0.508	–0.0208	0.883	0.2434	0.420	–0.3051	0.187
VEGETA	0.0004	0.920	0.0218	0.291	–0.0557	0.208	–0.0532	0.117
FAT	0.0525	0.000	–0.3334	0.000	–0.0546	0.709	–0.2042	0.069
DOC	0.0037	0.000	–0.0077	0.022	0.0110	0.127	–0.0145	0.009
HS_WORKER	0.0043	0.098	–0.0034	0.803	–0.0203	0.484	0.0064	0.772
BED	–0.0043	0.161	0.0032	0.839	0.0131	0.697	–0.0284	0.271
THE	0.0126	0.106	–0.1593	0.000	0.0212	0.807	–0.1150	0.044
VACCINE	0.0196	0.057	–0.2177	0.000	–0.4480	0.000	–0.4224	0.000
R		.768		.795		.764		.728
Adjusted *R*		.757		.786		.753		.716
R change		.019		.019		.008		.018
Obs.		27(513)		27(513)		27(513)		27(513)

Note. LE = life expectancy at birth; MOR = mortality rate; IMR = infant mortality rate; PYLL = potential years of life lost; GDP = gross domestic product per capita; CLF = civilian labor force; *SE* = school life expectancy; UNEMP = unemployed for more than 6 months, percentage of unemployment (15+); WASTE = wastewater treatment rate, percent; NO_X = nitrogen oxides, kilograms per capita; PM10 = particulate matter, less than or equal to 10 μm, kilograms per capita; SO_X = sulfur oxides, kilograms per capita; ALC = alcohol consumption, liters per capita (15+); SMO = tobacco consumption, grams per capita (15+); SUGAR = sugar intake, per capita; CAL = calorie supply, per capita; VEGETA = vegetable intake, per capita; FAT = fat intake, per capita; DOC = number of doctors, per 1,000; HS_WORKER = number of medical and social workers, per 1,000; BED = number of hospital beds, per million; THE = total health expenditure, GDP percent; VACCINE = vaccination coverage of measles, percent; Obs. = number of observations.

Multicollinearity

The variance inflation factors (VIF) were analyzed to check for multicollinearity between the explanatory variables. The analysis showed that the VIF was below 10 for all variables and that the average VIF was also relatively low at 2.58, so no multicollinearity problem was found.

Health Determinants in a Fixed Effects Model

When LE was the dependent variable, GDP (0.0566), UNEMP (0.0065), NO_X (–0.0133), SMO (–0.0086), SUGAR (0.0078), FAT (0.0525), and DOC (0.0370) had statistically significant effects, and the adjusted R^2 value was 75.7%. When MOR was the dependent variable, GDP (–0.3056), NO_X (0.0925), ALC (0.0784), SMO (0.0487), FAT (–0.3334), DOC (–0.0077), THE (–0.1593), and VACCINE (–0.2177) had statistically significant effects, and the adjusted R^2 value was 78.6%. When IMR was the dependent variable, GDP (–0.6456), SE (–0.3882), WASTE (–0.2019), and VACCINE (–0.4480) had statistically significant effects, and the adjusted R^2 value was 75.3%. When PYLL was the dependent variable, GDP (–0.4011), NO_X (0.1123), ALC (0.1115), SMO (0.0447), DOC (–0.0145), THE (–0.1150), and VACCINE (–0.4224) were statistically significant, and the adjusted R^2 value was 71.6%. See Table 2 for more details.

The results of the fixed-effect regression analyzing the SDH affecting each health outcome were compiled (see Supplementary Table 1). First, in terms of the socioeconomic factors, GDP had a positive effect on all results, being positively correlated with LE and negatively correlated with PYLL, MOR, and IMR. CLF did not have a significant effect on health outcomes, whereas SE had a considerable effect in reducing IMR. UNEMP and LE had a significantly positive relationship. For the physical environment factors, WASTE was negatively correlated with IMR and PYLL, and NO_X had a negative effect on health outcomes. PM10 and SO_X had no effect on health outcomes in this study. For the health behavior factors, ALC was positively correlated with MOR and PYLL, and SMO was negatively correlated with LE and positively correlated with PYLL and MOR; these factors therefore had a negative effect on three health outcomes. FAT had a beneficial effect on health outcomes, as it was positively correlated with LE and negatively correlated with MOR, and CAL and VEGETA did not have significant effects on any health outcome. For the health service factors, DOC was positively correlated with LE and negatively correlated with MOR and PYLL. THE was negatively correlated with MOR and PYLL, and VACCINE was negatively correlated with MOR, IMR, and PYLL. Thus, these factors had a positive effect on health outcomes.

Discussion

Numerous panel studies have focused on OECD countries. However, the studies' findings have differed, as each study focused on different subject countries and different dependent and independent variables representing health outcomes and SDH. Accordingly, the panel analysis in this study comprehensively approaches the main indicators of health outcomes, LE, PYLL, MOR, and IMR, by setting them as the dependent variables and by applying and analyzing as many determinants as possible to avoid the limitations of previous studies, which incorporated fewer than 10 independent variables.

In general, national health levels are positively related to economic power (Ashraf, Lester, & Weil, 2008) because resource abundance influences health determinants such as nutrition, lifestyle, medical services, and the environment. This study aimed to identify the current health levels of the relatively healthy OECD countries. Among the socioeconomic factors, GDP had a significantly positive relationship with LE, whereas it was significantly negatively related to MOR, IMR, and PYLL. This finding is identical to findings of previous studies (Or, 2000; Joumard, André, Nicq, & Chatal, 2010), which considered GDP to be positively related to health. SE affected only IMR and had a strong influence on the reduction of IMR. Although past studies have continually claimed that education level is related to health outcomes, womenMR education level is known to be more strongly related to IMR (Mathews, Menacker, & MacDorman, 2003). Although this outcome is partially due to education level's relationship to socioeconomic factors, a lower education level raises the low birth weight infant rate (Gisselmann, 2005). Although a clear reason for this result has not been identified, education is inferred to not only empower families in terms of their productivity and health but also enhance parents' judgment and skills in fostering healthier children (Papageorgiou & Stoytcheva, 2008). UNEMP was determined to have a positive effect on SE, a result that somewhat diverges from previous studies, in which unemployment was found to be non-significant (López-Casasnovas & Soley-Bori, 2014). Unemployment is typically seen as a negative factor and is known to decrease health levels (Hergenrather, Zeglin, McGuire-Kuletz, & Rhodes, 2015). However, although various studies found that unemployment and health are negatively related at an individual level, unemployment and economic recession are known to improve health-related indicators (excluding the suicide mortality rate) at a population level (Hergenrather et al., 2015; Toffolutti & Suhrcke, 2014).

Examining the physical environment factors, WASTE had a negative effect on PYLL and IMR. Water is a fundamental substance necessary for human survival. As unsanitary drinking water has a negative effect on health (Gundry, Wright, & Conroy, 2004) and untreated polluted water threatens public health by increasing the frequency of disease outbreaks (Prüss, Kay, Fewtrell, & Bartram, 2002), wastewater treatment is considered a means of increasing health levels (Craun, 1988). NO_X is an emission source from cars, planes, industrial boilers, and incinerators, and emphysema and respiratory diseases are among the main ailments caused by NO_X. This variable had a negative effect on health, as it was negatively correlated with LE and positively correlated with MOR and PYLL, consistent with the results of studies by Jeong, Lee, and Shin (2007).

In terms of health behavior factors, ALC was related to an increase in MOR and PYLL, and SMO was related to a reduction in LE and an increase in MOR and PYLL. Alcohol and tobacco are the most important health risk factors. Although there are minor differences among the studies, this finding agrees with previous studies claiming that alcohol and tobacco have a negative influence on health. FAT had a positive effect on health, as it was positively correlated with LE and negatively correlated with MOR. With the overconsumption caused by progress in civilization and agricultural technology, it is commonly accepted that a reduction in fat intake is beneficial. Nonetheless, fat is one of the three main macronutrients and is necessary for the human body, as it is a building block for hormones and cells. Excessive consumption of fat leads to obesity and becomes a causal factor for cardiovascular diseases, but a deficiency may cause fatigue and weaken immunity. However, as previous studies indicate that the consumption of fat has a beneficial effect on health (Hooper et al., 2001), further research is necessary at the state level to verify this claim.

Among health service factors, DOC was positively correlated with LE and negatively correlated with PYLL and MOR, showing its beneficial effect on health. This result is in line with previous studies conducted on OECD countries. THE was negatively correlated with MOR and PYLL, whereas it was considered to be positively related to health in a variety of ways, including LE and IMR. VACCINE was negatively correlated with PYLL, MOR, and IMR and had positive effects on health outcomes, with especially high effects on PYLL and IMR (Jeong et al., 2007; Nixon & Ulmann, 2006). The measles vaccine is used as a proxy, but the reductions in PYLL and IMR should be attributed to the good immunization standards of public health systems rather than solely to the prevention of measles (Hyde et al., 2012).

Furthermore, as the dependent variables are all standardized by a *z* transformation, we can see which independent variables have more influence on which health outcome. SMO affects LE, MOR, and PYLL, but it contributes more to MOR (0.0487) and PYLL (0.0447) than to LE (0.0096), and VACCINE has the largest contribution to IMR (–0.4490). The indicators with consistent results for two or more health outcomes were GDP, WASTE, NO_X, ALC, SMO, FAT, DOC, and VACCINE. In previous studies on the SDH, socioeconomic factors typically had the greatest effect in traditional macroscopic analyses at a national level, and GDP was found have a greater influence in this study as well. However, improvements at the GDP level surpass the scope of this study. Thus, it was excluded from this study's discussions.

Limitations

One of this study's limitations is that it does not fully incorporate all of the determinants that affect health. Social capital and support is an important socioeconomic and health behavior factor that influences health. However, this factor was not considered, as not all countries provided indices for this factor, and its longitudinal scope was too short. In terms of physical environmental factors, only water and air pollution indicators were considered, and other pollutants, such as climate change (in relation to global warming), disasters, soil, and noise were not considered. Furthermore, indicators related to physical activity were also not considered. For health service factors, this study is limited in that it incorporates only quantitative indicators. Although the numbers of doctors and beds, along with the value for THE, are meaningful, they cannot illustrate the general quality of health services. Due to the difficulty in quantifying the qualitative factors affecting national health, such as public and private insurance, medical delivery systems, policies, and planning, such factors were not included in this study.

Conclusion

To improve national level health outcomes in industrialized countries, tobacco and alcohol controls and nutritional policies, which will contribute comparatively more to mortality and PYLL reductions, should be strengthened first among health behavioral interventions. In terms of health systems, policies regarding the number of doctors should be adjusted and vaccine policies should be strengthened. In particular, vaccine coverage will contribute more to IMR and PYLL reductions. Finally, in terms of environmental health, we suggest strengthening waste treatment and air pollution policies.

Author Contributions

M.-B.P. led and designed the study. E.W.N. reviewed the literature and checked the statistical methods. All authors reviewed and approved the final manuscript.

Author's Note

All data can be found at "https://stats.oecd.org." If you need the processed data, please contact the author to request the data. This manuscript has not been published or presented elsewhere in part or in entirety, and is not under consideration by another journal.

Ethical Approval

This study was conducted in accordance with the Declaration of Helsinki, and the article does not contain any studies with human participants or animals that were conducted by any of the authors.

Declaration of Conflicting Interests

The author(s) declared no potential conflicts of interest with respect to the research, authorship, and/or publication of this article.

Funding

The author(s) disclosed receipt of the following financial support for the research, authorship, and/or publication of this article: This work was supported by a research grant from Pai Chai University in 2019.

Supplemental Material

Supplemental material for this article is available online.

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