ORIGINAL RESEARCH

Predictors of (in)efficiencies of Healthcare Expenditure Among the Leading Asian Economies – Comparison of OECD and Non-OECD Nations

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Purpose: The goal of this study was to assess the effectiveness of healthcare spending among the leading Asian economies.

Methods: We have selected a total of nine Asian nations, based on the strength of their economic output and long-term real GDP growth rates. The OECD members included Japan and the Republic of Korea, while the seven non-OECD nations were China, India, Indonesia, Malaysia, Pakistan, the Philippines, and Thailand. Healthcare systems efficiency was analyzed over the period 1996–2017. To assess the effectiveness of healthcare expenditure of each group of countries, the two-way fixed effects model (country- and year effects) was used.

Results: Quality of governance and current health expenditure determine healthcare system performance. Population density and urbanization are positively associated with a healthy life expectancy in the non-OECD Asian countries. In this group, unsafe water drinking has a statistically negative effect on healthy life expectancy. Interestingly, only per capita consumption of carbohydrates is significantly linked with healthy life expectancy. In these non-OECD Asian countries, unsafe water drinking and per capita carbon dioxide emissions increase infant mortality. There is a strong negative association between GDP per capita and infant mortality in both sub-samples, although its impact is far larger in the OECD group. In Japan and South Korea, unemployment is negatively associated with infant mortality.

Conclusion: Japan outperforms other countries from the sample in major healthcare performance indicators, while South Korea is ranked second. The only exception is per capita carbon dioxide emissions, which have maximal values in the Republic of Korea and Japan. Non-OECD nations' outcomes were led by China, as the largest economy. This group was characterized with substantial improvement in efficiency of health spending since the middle of the 1990s. Yet, progress was noted with remarkable heterogeneity within the group.

Keywords: Asia, health expenditure, healthy life expectancy, infant mortality, nutrition, population health outcomes

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Introduction

Efficiency of healthcare attributable spending is quite an old concept in the theory of health economics. It can even be dated back to the early works of Milton Friedman[1] and Selma Mushkin[2] back in the 1930s and early 1950s. Over the course of many decades, this concept has substantially evolved in seminal literature. Health economics principles, grounded in theoretical concepts, like the Human

Capital approach,[3] were largely based on the value of statistical life hypothesis.[4] In Marxist theory, these notions and practice remained poorly understood for decades and were even regarded as unethical[5] by the socialist policy-makers in the East Asia region.[6] In these countries, healthcare, just like education, was regarded as a consumption branch of the national economy, instead of being a productive one – a role typically reserved for the industry. Social equality in access to healthcare was deemed to be a constitutional civil right and was generally truly exercised in reality, to a large extent.[7] Predictably, purchasing power for medical goods and services was much better in coastal, industrial and urban areas in comparison to the rural countryside.[8] Yet, the social inequalities in these countries, in many areas of life, healthcare alike, began to deepen actually with the arrival of free-market reforms in typical real-socialism societies.[9] Changes visible today, in a Chinese mainland model, are mirrored in most other surrounding nations, regardless of a formerly socialist social order.

This study aimed to assess the effectiveness of healthcare spending among the leading Asian countries. These nine observed nations were selected for the purpose of this research, based on the strength of their economic potential and contribution to the rapidly developing, new geo-economic epicenter of worldwide activity, with its heavyweight geographically located in Southeast Asia.[10] Depending on their dominant social pattern, they might be roughly divided alongside their OECD membership. The OECD members are Japan and the Republic of Korea, and the remaining seven non-OECD nations are: China, India, Indonesia, Malaysia, Pakistan, the Philippines, and Thailand. There are a few core indicators of population health, such as human longevity and early childhood survival, which might be regarded as particularly sensitive performance indicators of health system efficiency.[11] These public health outcomes actually measure the capability of a certain health system to deliver, to its citizens, the quantity and quality of health needed for the nation.[12] There is a large body of evidence in published literature, providing reliable grounds for comparison within and outside this region.[13] Thus, we attempted to measure the impact of the variety of lifestyle and economic underlying factors with the capability to influence these deliverables. In a later step, we compared these two groups of countries in the sense of their overall system effectiveness. Closer methodological explanations and results follow beneath.

Materials and Methods
Theoretical Framework

We decided to apply comprehensive knowledge broadly adopted in econometrics on causes and consequences of cost-effective resource allocation in medicine, to the most rapidly developing and high-income Asian nations. Most seminal studies so far refer to North America, Western Europe and Japan on underlying drivers of health expenditure. Yet, there is scarcity of such studies on China, India, and surrounding low- and middle-income countries of Asia. The major UN multilateral agencies and academic literature alike broadly recognized that this region remains a driver of real GDP growth worldwide.[15] Thus, we attempted to partially fill this knowledge gap while applying principles of health economics, well familiar to free-market economies, to some of these nations with significant centrally controlled economic sectors. A particularly important part of our consideration was comparison of a scale between rich OECD societies and slightly lagging behind, non-OECD nations. Although our theoretical framework might sound simplistic to some extent, we intended to bring important transnational and comparative conclusions. Such knowledge would otherwise be impossible to generate with a focus on a single market or a limited sample of smaller to medium population-sized nations. Thus, we attempted to open a public debate on respective strengths and weaknesses among their mutually complementary or competing regional health policies. Furthermore, we believe such endeavor might spark interest for the Asian policy-makers and provide insights for these health systems to learn from each other's historical successes and failures.

In the theoretical framework, it was our assumption that healthy life expectancy, infant mortality and under-five mortality are the key performance indicators of healthcare effectiveness. These efficiency indicators are typical in the literature (see a summary by Kim and Kang: p.26).[16] The main factors directly contributing to a human health condition are balanced nutrition,[17] high quality of drinking water,[18] high air quality,[17] and sufficient physical activity.[19] The most important indirect factors include socio-economic conditions, quality of governance,[18,20] health expenditure,[17,18] and physicians' density.[17] Importantly, although indirect factors, like high income per capita,[17,18] high health expenditure or urbanization,[18] are very influential, they do not imply optimal values of direct factor quality, such as, for example, diet composition. Eg, high per capita healthcare expenditure does not

necessarily mean that an average citizen receives balanced nutrition, and vice versa. Therefore, a complex approach is necessary to assess healthcare system effectiveness by looking at the impact of both groups of factors, direct and indirect, on the key performance indicators.

Sample and Data Collection Procedure

Diet composition data were obtained from the Food and Agriculture Organization (FAO).[21] The main healthcare system and economic characteristics were collected from the World Health Organization (WHO) and the World Bank (WB) databases, while some specific information on the environmental situation, for each country, were obtained from the Socioeconomic Data and Applications Center (SDAC). Healthcare systems efficiency is analyzed over the period 1996–2017. Thus, the final sample consists of 198 observations for nine Asian countries: Japan, China, India, Indonesia, the Republic of Korea, Malaysia, Pakistan, the Philippines, and Thailand.

Method

To assess the effectiveness of healthcare expenditure from the selected group of Asian countries, the following two-way fixed effects model (country- and year effects) is used:

Dependent Variable$_{i,t}$ = δ_0 + δ_1 (Independent Variables) + δ_2 (Control Variables) + + δ_3 (Country Dummies) + δ_4 (Year Dummies) + α_i + u_t + $\varepsilon_{i,t}$ [Eq. 1]

Our dependent variables are infant mortality (WB: Mortality rate, per 1,000 live births), under-five mortality rate (WB: Mortality rate, under-five, per 1,000 live births) and healthy life expectancy (WHO: Healthy life expectancy at birth, years). Independent variables include current healthcare expenditure [(Global Health Expenditure Database: Current Health Expenditure (CHE) as percentage of Gross Domestic Product (GDP)] or current health expenditure per capita [(CHE) per capita, PPP (current international USD)]; regulatory quality or control of corruption (WB: World Governance Indicators); animal protein, plant protein, fat and carbohydrates consumption (FAO: the average per capita supply of calories derived from protein, fat, and carbohydrates, respectively, all measured in kilocalories per person per day); carbon dioxide emissions per capita (Our World in Data: CO2 metric tons per capita); unsafe water drinking index (SDAC: UWD). Control variables include GDP per capita in USD, PPP (WB: GDP per capita, PPP, constant 2011 international USD),

unemployment rate (WB: unemployment, total percentage of total labor force; modeled ILO estimate); real GDP growth ratio (The International Monetary Fund: Real GDP growth, annual percent change), population density (WB: people per sq. km of land area). Logarithmic transformations are applied if necessary as suggested by, eg, Wooldridge.[14] We add a square term for either component of diet composition in each regression, assuming the existence of certain optimal, per capita consumption levels for respective components. Table 1 presents a detailed description of all variables. The appendix contains a matrix of cross-correlations.

In our regression analysis, we compare the two sub-samples, seven non-OECD members (low- and middle-income countries) and two OECD members (the Republic of Korea and Japan, both high income), in order to identify predictors, which are specific for each sub-group.

We have also considered inclusion of other empirical methods such as Bayesian quantile regression method that was extensively used in scholarly literature.[22,23] This method assumes that the effects of independent variables differ across the quantiles of dependent variables. Yet, after thorough exploration, we concluded our ground assumptions where selected to be the ones described above. Thus, according to our best econometric assessment we picked up two-way fixed effects model as a convenient one to address our research question.

In addition, we utilize the counterfactual decomposition technique, popularized by Blinder[24] and Oaxaca,[25] which is widely used to study mean outcome differences between groups. The goal of decomposition analysis is to quantify the contribution of various factors to the change of outcomes or difference in outcomes between groups. For two groups, A and B, decomposition is formulated in terms of group B: how would group B perform if it had group A's endowment? Jann[26] provides a guide for Stata software to estimate our models.

Summary Statistics

Apparently, Japan outperforms other countries from the sample in major healthcare performance indicators like life expectancy and infant mortality. The Republic of Korea is ranked second. Not surprisingly, the main contributing factors, which affect, directly or indirectly, the health of people in the two countries, have either the best or second best values. The only exception is per capita

Table 1 Descriptive Statistics

Variables	Obs	Mean	Std. Dev.	Min	Country (Min)**	Max	Country (Max)**
Healthy life expectancy, years	45	64.032	6.020	53.518	Pakistan	74.812	Japan; Korea (73.036)
Healthy life expectancy*, years	198	63.387	6.030283	51.000	Pakistan	74.956	Japan; Korea (73.036)
Infant mortality, per 1,000 live births	198	26.490	24.369	1.900	Japan; Korea (2.8)	95.500	Pakistan
Under-five mortality, per 1,000 live births	198	33.455	31.696	2.600	Japan; Korea (3.3)	123.500	Pakistan
Current health expenditure per capita	162	784.356	1043.901	79.590	Pakistan	4,592.428	Japan; Korea (2711.738)
Current health expenditure as a share of GDP	198	4.235	1.923	1.900	India	10.940	Japan; Korea (7.60)
CO_2 emissions per capita, tonnes per year	198	4.446	3.629	0.727	Pakistan	12.085	Korea; Japan (10.241)
Unsafe water drinking	36	666.802	945.512	4.045	Japan; Korea (4.580)	3,869.846	India
Unsafe water drinking*	198	701.016	998.389	3.422	Japan; Korea (4.580)	4,512.430	India
Animal protein consumption, kilocalories per person per day	126	118.389	51.872	38.520	Indonesia	223.720	Japan
Animal protein consumption, kilocalories per person per day*	198	118.295	52.378	38.280	Indonesia	223.720	Japan
Plant protein consumption, kilocalories per person per day	126	167.076	29.038	127.000	Philippines	233.600	China
Plant protein consumption, kilocalories per person per day*	198	167.622	29.378	126.040	Philippines	233.600	China
Fat consumption, kilocalories per person per day	126	628.826	160.990	396.180	India	946.890	Korea; China (862.83); Japan (815.49)
Fat consumption, kilocalories per person per day*	198	625.098	163.501	383.130	India	946.890	Korea; China (862.83); Japan (815.49)
Carbohydrates consumption, kilocalories per person per day	126	1781.455	155.924	1431.220	Pakistan; Japan (1546.85)	2,048.390	Korea
Carbohydrates consumption, kilocalories per person per day*	198	1792.202	156.009	1431.220	Pakistan; Japan (1546.85)	2,107.920	Korea
Regulatory quality [−2.5; 2.5]***	180	0.114	0.585	−0.905	Pakistan	1.428	Japan
Regulatory quality* [1; 6]***	198	2.015	0.573	1.000	Pakistan	3.333	Japan
Control of corruption [−2.5; 2.5]***	180	−0.148	0.698	−1.220	Indonesia	1.695	Japan; Korea (0.624)
Control of corruption* [1; 6]***	198	2.073	0.695	1.000	Indonesia	3.915	Japan; Korea (2.834)
GDP per capita	198	13632.990	11068.280	2334.300	Indonesia	38,907.370	Japan; Korea (36,776.519)
Real GDP growth	198	4.815	3.535	−13.100	Japan	14.300	China
Unemployment	198	3.329	1.569	0.398	Pakistan	8.060	Indonesia; Japan (5.400)
Population density	198	248.106	138.551	63.971	Malaysia	527.918	Korea
Urbanization	198	52.781	19.782	26.817	India	91.535	Japan

Notes: *Denotes that data imputations based on linear model estimates were made for missing observations; **In columns "Country (min)" and "Country (max)", the first country name refers to a country with the minimal (maximal) value respectively. The following country names (if any), with respective values in parentheses; refer to respective countries, which stay second (and third) if ascending (descending) of the values is applied; ***Regulatory quality and Control of corruption are continuous variables. The higher values mean the higher [regulatory] quality or better control [of corruption] respectively.

carbon dioxide emissions, which have maximal values in the Republic of Korea and Japan.

Results

Tables 2–4 demonstrate that regression analysis, with sub-samples, is useful for identifying predictors of infant mortality, under-five mortality and healthy life expectancy, which are specific to the OECD-members with outstanding healthcare outcomes among the analyzed countries, compared to other Asian countries from our sample.

Predictors of Infant Mortality in the Leading Asian Countries

Regressions (2.1)-(2.4), from Table 2, contain the OLS estimates of our model given in Eq. (1) for infant mortality. Regressions (2.1) and (2.2) present the results from estimating a version of Eq. (1) with current health expenditure in GDP, for OECD and non-OECD countries, respectively. Similarly, regressions (2.3) and (2.4) provide the results from estimating a version of Eq. (1) with per capita current health expenditure, for OECD and non-OECD countries,

Table 2 Predictors of Infant Mortality in Nine Asian Countries: Log-Linear Regression Estimates

Variables	ln(Infant Mortality)			
	(2.1)	(2.2)	(2.3)	(2.4)
	OECD	Non-OECD	OECD	Non-OECD
CHE as a share of GDP	0.0363 (0.0718)	−0.193*** (0.0492)		
ln(CHE per capita)			0.215 (0.346)	−0.238*** (0.0691)
Regulatory quality [1; 6]	0.0932 (0.180)	−0.393*** (0.0948)	1.288 (0.945)	−1.128*** (0.144)
Regulatory quality*CHE/GDP	−0.0166 (0.0233)	0.153*** (0.0280)		
Regulatory quality*ln(CHE pc)			−0.168 (0.122)	0.225*** (0.0259)
ln(Unsafe water drinking)	−0.346* (0.183)	0.0981*** (0.0147)	0.0968 (0.304)	0.0757*** (0.0128)
ln(CO_2 per capita)	0.124 (0.209)	0.115** (0.0534)	0.204 (0.250)	0.182*** (0.0496)
ln(Animal protein consum. pc)	12.52** (5.763)	0.987 (0.860)	−1.799 (10.62)	0.786 (1.110)
ln(Animal protein consum. pc)Sq	−1.239** (0.565)	−0.106 (0.103)	0.155 (1.038)	−0.128 (0.132)
ln(Plant protein consum. pc)	153.7*** (30.82)	11.43** (5.083)	79.19 (46.43)	−1.674 (5.801)
(ln(Plant protein consum. pc))Sq	−14.49*** (2.922)	−1.194** (0.500)	−7.460 (4.405)	0.141 (0.573)
ln(Carbohydrates consum. pc)	−133.9*** (33.64)	41.76** (16.33)	−51.33 (55.22)	63.10*** (14.81)
(ln(Carbohydrates consum. pc))Sq	8.850*** (2.230)	−2.765** (1.088)	3.349 (3.667)	−4.228*** (0.986)
ln(Fat consumption pc)	−4.312 (15.39)	−5.605 (3.774)	4.202 (19.80)	−3.716 (4.504)
(ln(Fat consumption pc))Sq	0.310 (1.144)	0.424 (0.306)	−0.345 (1.477)	0.303 (0.363)
ln(GDP per capita)	−1.861*** (0.319)	−0.359*** (0.0553)	−0.857 (0.606)	−0.623*** (0.104)
Unemployment	−0.0251** (0.0112)	−0.0202*** (0.00614)	−0.0164 (0.0218)	−0.00781 (0.00623)
ln(Population density)	3.786** (1.717)	−0.214*** (0.0758)	1.144 (2.638)	−0.0440 (0.0911)
Urbanization	−0.0113 (0.00680)	−0.0283*** (0.00223)	−0.0136 (0.00923)	−0.0273*** (0.00248)

(*Continued*)

Table 2 (Continued).

Variables	ln(Infant Mortality)			
	(2.1)	(2.2)	(2.3)	(2.4)
	OECD	**Non-OECD**	**OECD**	**Non-OECD**
Constant	81.93	−160.1**	−18.82	−209.5***
	(87.45)	(61.90)	(108.0)	(59.14)
Observations	44	154	36	126
R-squared	0.997	0.980	0.996	0.982
Number of countries	2	7	2	7

Notes: Standard errors in parentheses, ***<0.01; **P<0.05; *P<0.1.

respectively. In our regressions, we interact current health expenditure as a share of GDP (2.1 and 2.2) or per capita current health expenditure (2.3 and 2.4) with regulatory quality and include this as an additional independent variable. To capture the direct effect of regulatory quality on infant mortality, we also include regulatory quality independently.

The main result here is that, in non-OECD Asian countries, both interaction terms of regulatory quality, with either current health expenditure as a share of GDP, or per capita current health expenditure, are significant at the 1%-level (coefficients of 0.153 and 0.225, respectively). The results suggest that one percentage point increase in the share of health expenditure in GDP is associated with a 19.3% decline in infant mortality (significant at the 1%-level). Similarly, one percentage point growth of per capita health expenditure is linked with a 23.8% decrease in infant mortality (significant at the 1%-level). Regulatory quality is negative and statistically significant at the1%-level in both model specifications: (2.2) and (2.4). In addition, statistically significant interaction terms imply that the better regulatory quality is, the larger becomes the effect of the share of health expenditure in GDP on infant mortality (or alternatively, the worse regulatory quality is, the smaller the effect of the share of health expenditure in GDP on infant mortality becomes). As for direct factors, in non-OECD Asian countries, unsafe water drinking and per capita carbon dioxide emissions increase infant mortality. Interestingly, only per capita consumption of carbohydrates and its square term are statistically significantly linked with infant mortality in non-OECD Asian countries, suggesting the existence of a non-linear relationship between the two variables. The results of the estimates, with control of corruption,

included instead of regulatory quality, are qualitatively the same (see Supplementary Material 1). Both regulatory quality and control of corruption are indicators of the quality of governance calculated by the World Bank.[20] Simultaneous inclusion of both indicators in one model would cause multicollinearity problem as the two indicators are highly correlated (see Appendix).

Regarding the effects of control variables, there is a strong negative association between GDP per capita and infant mortality in both sub-samples, although its impact is far larger in Japan and the Republic of Korea. Predictably, in non-OECD Asian countries, urbanization has a negative impact on infant mortality, statistically significant at the 1%-level as population has better access to medical facilities: models (2.2) and (2.4).

Predictors of Under-Five Mortality in the Leading Asian Countries

Regressions (3.1)-(3.4), from Table 3, contain the OLS estimates of our model given in Eq. (1) for under-five mortality. Regressions (3.1) and (3.2) present the results from estimating a version of Eq. (1) with current health expenditure in GDP, for OECD and non-OECD countries, respectively. Similarly, regressions (3.3) and (3.4) provide the results from estimating a version of Eq. (1) with per capita current health expenditure, for OECD and non-OECD countries, respectively. In our regressions, we interact current health expenditure as a share of GDP (3.1 and 3.2) or per capita current health expenditure (3.3 and 3.4) with regulatory quality and include this as an additional independent variable. To capture the direct effect of regulatory quality on under-five mortality, we also include regulatory quality independently.

Table 3 Predictors of Under-Five Mortality in Nine Asian Countries: Log-Linear Regression Estimates

Variables	ln(Under-Five Mortality)			
	(3.1)	**(3.2)**	**(3.3)**	**(3.4)**
	OECD	**Non-OECD**	**OECD**	**Non-OECD**
CHE as a share of GDP	0.0362 (0.104)	−0.220*** (0.0531)		
ln(CHE per capita)			0.227 (0.579)	−0.253*** (0.0777)
Regulatory quality [1; 6]	0.0804 (0.260)	−0.459*** (0.102)	1.079 (1.579)	−1.241*** (0.162)
Regulatory quality*CHE/GDP	−0.0115 (0.0337)	0.172*** (0.0302)		
Regulatory quality*ln(CHE pc)			−0.138 (0.204)	0.245*** (0.0291)
ln(Unsafe water drinking)	−0.413 (0.265)	0.102*** (0.0158)	0.0539 (0.509)	0.0760*** (0.0144)
ln(CO_2 per capita)	0.0738 (0.303)	0.117** (0.0576)	0.154 (0.418)	0.189*** (0.0558)
ln(Animal protein consum. pc)	11.26 (8.328)	0.685 (0.927)	6.493 (17.75)	−0.131 (1.249)
ln(Animal protein consum. pc)Sq	−1.112 (0.816)	−0.0783 (0.111)	−0.656 (1.734)	−0.0298 (0.148)
ln(Plant protein consum. pc)	114.1** (44.54)	14.29** (5.484)	15.81 (77.60)	−2.278 (6.525)
(ln(Plant protein consum. pc))Sq	−10.78** (4.222)	−1.480*** (0.540)	−1.474 (7.362)	0.201 (0.645)
ln(Carbohydrates consum. pc)	−109.8** (48.60)	44.09** (17.62)	−8.445 (92.29)	68.06*** (16.66)
(ln(Carbohydrates consum. pc))Sq	7.297** (3.222)	−2.925** (1.174)	0.561 (6.129)	−4.567*** (1.109)
ln(Fat consumption pc)	5.860 (22.24)	−5.897 (4.072)	14.33 (33.09)	−3.303 (5.066)
(ln(Fat consumption pc))Sq	−0.449 (1.653)	0.441 (0.331)	−1.099 (2.469)	0.266 (0.408)
ln(GDP per capita)	−2.204*** (0.461)	−0.374*** (0.0596)	−1.199 (1.013)	−0.685*** (0.117)
Unemployment	−0.0338** (0.0161)	−0.0214*** (0.00662)	−0.0188 (0.0365)	−0.00969 (0.00700)
ln(Population density)	5.419** (2.481)	−0.288*** (0.0817)	2.097 (4.409)	−0.0966 (0.102)
Urbanization	−0.0113 (0.00983)	−0.0275*** (0.00241)	−0.0207 (0.0154)	−0.0266*** (0.00279)

(*Continued*)

Table 3 (Continued).

Variables	ln(Under-Five Mortality)			
	(3.1)	(3.2)	(3.3)	(3.4)
	OECD	**Non-OECD**	**OECD**	**Non-OECD**
Constant	56.79 (126.4)	−173.0** (66.78)	−72.46 (180.6)	−224.0*** (66.53)
Observations	44	154	36	126
R-squared	0.993	0.980	0.988	0.979
Number of countries	2	7	2	7

Notes: Standard errors in parentheses, ***<0.01; **P<0.05; *P<0.1.

The key result here is that, in non-OECD Asian countries, both interaction terms of regulatory quality with either current health expenditure as a share of GDP or per capita current health expenditure are significant at the 1%-level (coefficients of 0.172 and 0.245, respectively). The results suggest that a one percentage point increase in the share of health expenditure in GDP is associated with a 22% decline in under-five mortality (significant at the 1%-level). Similarly, a one percentage point growth of per capita health expenditure is linked with a 25.3% decrease in under-five mortality (significant at the 1%-level). Regulatory quality is negative and statistically significant at the 1%-level in both model specifications: (3.2) and (3.4). In addition, positive and statistically significant interaction terms imply that the better regulatory quality is, the larger becomes the effect of the share of health expenditure in GDP on under-five mortality (or alternatively, the worse regulatory quality is, the smaller the effect of the share of health expenditure in GDP on under-five mortality becomes). As for direct factors, in non-OECD Asian countries, unsafe water drinking and per capita carbon dioxide emissions increase under-five mortality. Interestingly, only per capita consumption of carbohydrates and its square term are statistically significantly linked with under-five mortality in non-OECD Asian countries, suggesting the existence of a non-linear relation between the two variables. Results of the estimates with control of corruption, included instead of regulatory quality, are qualitatively the same (see Supplementary Material 2).

Regarding the effects of control variables, there is a strong negative association between GDP per capita and under-five mortality in both sub-samples, although its impact is far larger in Japan and the Republic of Korea. Predictably, in non-OECD Asian countries, urbanization has a negative impact on under-five mortality, statistically significant at 1%-level in models (3.2) and (3.4).

Predictors of Healthy Life Expectancy in the Leading Asian Countries

Regressions (4.1)-(4.4), from Table 4, contain the OLS estimates of our model given in Eq. (1) for healthy life expectancy. Although more than three quarters (77.3%) of observations of our dependent variable are multiple imputations, we consider these estimates as insightful supporting evidence. Regressions (4.1) and (4.2) present the results from estimating a version of Eq. (1) with current health expenditure in GDP, for OECD and non-OECD countries, respectively. Similarly, regressions (4.3) and (4.4) provide the results from estimating a version of Eq. (1) with per capita current health expenditure, for OECD and non-OECD countries, respectively. In our regressions, we interact current health expenditure as a share of GDP (4.1 and 4.2) or per capita current health expenditure (4.3 and 4.4) with regulatory quality and include this as an additional independent variable. To capture the direct effect of regulatory quality on healthy life expectancy, we also include regulatory quality independently.

The main result here is that, in non-OECD Asian countries, both interaction terms of regulatory quality, with either current health expenditure as a share of GDP, or per capita current health expenditure, are significant at the 1%-level (coefficients of −0.015 and −0.020, respectively). The results suggest that a one percentage point increase in the share of health expenditure in GDP is associated with a three percent growth in healthy life expectancy (significant at the 1%-level). Similarly, a one percentage point growth of per capita health expenditure is linked with a 2.1% growth in healthy life expectancy.

Table 4 Predictors of Healthy Life Expectancy in Nine Asian Countries: Log-Linear Regression Estimates

Variables	ln(Healthy Life Expectancy)			
	(4.1)	(4.2)	(4.3)	(4.4)
	OECD	**Non-OECD**	**OECD**	**Non-OECD**
CHE as a share of GDP	0.00309 (0.00568)	0.0302*** (0.00920)		
ln(CHE per capita)			−0.00225 (0.0198)	0.0212* (0.0111)
Regulatory quality [1; 6]	0.00981 (0.0142)	0.0592*** (0.0177)	−0.0610 (0.0541)	0.116*** (0.0231)
Regulatory quality*CHE/GDP	−0.000737 (0.00184)	−0.0154*** (0.00523)		
Regulatory quality*ln(CHE pc)			0.00794 (0.00697)	−0.0204*** (0.00415)
ln(Unsafe water drinking)	0.0457*** (0.0145)	−0.0114*** (0.00274)	−0.000572 (0.0174)	−0.00613*** (0.00206)
ln(CO$_2$ per capita)	−0.0103 (0.0166)	0.00788 (0.00998)	−0.0178 (0.0143)	−0.0139* (0.00796)
ln(Animal protein consum. pc)	−1.085** (0.456)	0.0184 (0.161)	−0.626 (0.608)	0.370** (0.178)
ln(Animal protein consum. pc)Sq	0.105** (0.0447)	0.000156 (0.0192)	0.0595 (0.0594)	−0.0399* (0.0212)
ln(Plant protein consum. pc)	−12.19*** (2.439)	−1.651* (0.950)	−4.230 (2.658)	1.687* (0.931)
(ln(Plant protein consum. pc))Sq	1.157*** (0.231)	0.151 (0.0935)	0.401 (0.252)	−0.177* (0.0920)
ln(Carbohydrates consum. pc)	10.96*** (2.662)	8.321*** (3.054)	3.544 (3.161)	4.531* (2.377)
(ln(Carbohydrates consum. pc))Sq	−0.728*** (0.176)	−0.552*** (0.203)	−0.236 (0.210)	−0.299* (0.158)
ln(Fat consumption pc)	1.408 (1.218)	2.136*** (0.706)	−1.200 (1.133)	0.599 (0.723)
(ln(Fat consumption pc))Sq	−0.107 (0.0905)	−0.164*** (0.0573)	0.0900 (0.0846)	−0.0492 (0.0582)
ln(GDP per capita)	0.183*** (0.0252)	−0.0321*** (0.0103)	0.0894** (0.0347)	0.0298* (0.0167)
Unemployment	0.00261*** (0.000884)	0.00178 (0.00115)	0.000684 (0.00125)	−0.000859 (0.001000)
ln(Population density)	−0.220 (0.136)	0.127*** (0.0142)	0.0935 (0.151)	0.159*** (0.0146)
Urbanization	−0.000777 (0.000539)	0.00326*** (0.000417)	−9.05e-05 (0.000528)	0.00297*** (0.000398)

(*Continued*)

Table 4 (Continued).

Variables	ln(Healthy Life Expectancy)			
	(4.1)	**(4.2)**	**(4.3)**	**(4.4)**
	OECD	**Non-OECD**	**OECD**	**Non-OECD**
Constant	−7.329	−30.32***	6.304	−21.00**
	(6.921)	(11.57)	(6.184)	(9.495)
Observations	44	154	36	126
R-squared	0.997	0.931	0.998	0.948
Number of countries	2	7	2	7

Notes: Standard errors in parentheses, ***<0.01; **P<0.05; *P<0.1.

Regulatory quality is positive and statistically significant at the 1%-level in both model specifications: (4.2) and (4.4). In addition, negative and statistically significant interaction terms imply that the better regulatory quality is, the smaller becomes the effect of the share of health expenditure in GDP on healthy life expectancy (or alternatively, the worse regulatory quality is, the larger the effect of the share of health expenditure in GDP on healthy life expectancy becomes). As for direct factors, in non-OECD countries, unsafe water drinking has a statistically negative effect on healthy life expectancy. Interestingly, only per capita consumption of carbohydrates and its square term are statistically significantly linked with healthy life expectancy in non-OECD Asian countries, suggesting the existence of an optimal level of per capita carbohydrates consumption associated with healthy life expectancy. The results of the estimates with control of corruption, included instead of regulatory quality, are qualitatively the same (see Supplementary Material 3).

Regarding the effects of control variables, population density and urbanization are positively associated with healthy life expectancy in non-OECD Asian countries. The respective coefficients are statistically significant at the 1%-level in models (4.2) and (4.4). In Japan and the Republic of Korea, per capita GDP is positively and statistically significantly linked with healthy life expectancy.

Decomposition Results

Table 5 demonstrates Oaxaca-Blinder decomposition of infant mortality in OECD and non-OECD countries. The first four columns represent the estimates with regulatory quality, while the last four columns – with control of corruption. In our sample, the mean of the ln(infant mortality) is 3.217 for non-OECD and 1.240 for OECD,

yielding a gap of −1.977. The decrease of −2.224 indicates that differences in endowments account for about 220% of the gap in ln(infant mortality). The second term (−1.049) quantifies the change in ln(infant mortality) when applying the OECD's coefficients to the non-OECD characteristics.

Table 6 demonstrates Oaxaca-Blinder decomposition of under-five mortality in OECD and non-OECD countries. The first four columns represent the estimates with regulatory quality, while the last four columns – with control of corruption. The mean of the ln(under-five mortality) is 3.424 for non-OECD and 1.476 for OECD, yielding a gap of −1.948. The decrease of −2.294 indicates that differences in endowments account for about 230% of the gap in ln(under-five mortality). The second term (−0.789) quantifies the change in ln(under-five mortality) when applying the OECD's coefficients to the non-OECD characteristics.

Table 7 demonstrates Oaxaca-Blinder decomposition of healthy life expectancy in OECD and non-OECD countries. The first four columns represent the estimates with regulatory quality, while the last four columns – with control of corruption. The mean of the ln(healthy life expectancy) is 4.108 for non-OECD and 4.272 for OECD, yielding a gap of 0.164. The increase of 0.297 indicates that differences in endowments account for about 29.7% of the gap in ln(healthy life expectancy). The second term (0.191) quantifies the change in ln (healthy life expectancy) when applying the OECD's coefficients to the non-OECD characteristics.

The results of the estimates for either key performance indicator with control of corruption, included instead of regulatory quality, are the same, except, of course, for overall endowments and coefficients. The results of the estimates with per capita current health expenditure,

Table 5 Oaxaca-Blinder Decomposition of Infant Mortality in Nine Asian Countries: Log-Linear Estimates with CHE as a Share of GDP

Variables	ln(Infant Mortality)							
	Overall	Endowments	Coefficients	Interaction	Overall	Endowments	Coefficients	Interaction
CHE as a share of GDP		−0.306 (0.344)	0.555 (0.424)	0.590 (0.454)		−0.118 (0.303)	0.125 (0.410)	0.133 (0.437)
Regulatory quality [1; 6]		−0.220 (0.178)	0.778* (0.471)	0.448* (0.272)				
Regulatory quality*CHE/GDP		0.808 (0.736)	−0.559 (0.354)	−1.291 (0.825)				
Control of corruption [1; 6]						−0.127 (0.208)	0.118 (0.402)	0.0900 (0.307)
Control of corruption*CHE/GDP						0.476 (0.774)	−0.205 (0.312)	−0.563 (0.858)
ln(Unsafe water drinking)		−1.061*** (0.110)	−3.159** (1.251)	2.304** (0.913)		−1.041*** (0.115)	−4.491*** (1.017)	3.276*** (0.745)
ln(CO_2 per capita)		−0.493*** (0.102)	0.403** (0.182)	0.863** (0.384)		−0.486*** (0.104)	0.634*** (0.147)	1.358*** (0.296)
ln(Animal protein consum. pc)		2.959*** (0.819)	38.81 (30.05)	6.053 (4.700)		3.057*** (0.904)	54.08* (29.74)	8.434* (4.665)
ln(Animal protein consum. pc)Sq		−3.198*** (0.929)	−16.40 (13.50)	−5.319 (4.390)		−3.293*** (1.022)	−23.01* (13.41)	−7.465* (4.370)
ln(Plant protein consum. pc)		2.076** (0.967)	565.7*** (179.0)	11.13*** (4.298)		2.332** (1.041)	628.0*** (198.4)	12.35*** (4.767)
(ln(Plant protein consum. pc))Sq		−2.005** (0.956)	−270.1*** (86.50)	−10.53** (4.134)		−2.254** (1.027)	−300.1*** (95.79)	−11.70** (4.583)
ln(Carbohydrates consum. pc)		0.867 (1.022)	−1,169*** (381.0)	−3.544 (2.970)		0.564 (0.846)	−1,250*** (390.6)	−3.790 (3.157)
(ln(Carbohydrates consum. pc))Sq		−0.889 (1.036)	578.5*** (189.5)	3.562 (2.953)		−0.584 (0.861)	616.3*** (194.1)	3.795 (3.127)
ln(Fat consumption pc)		−9.310*** (2.097)	33.43 (109.3)	1.880 (6.148)		−9.356*** (2.404)	−7.776 (117.4)	−0.437 (6.601)
(ln(Fat consumption pc))Sq		9.706*** (2.183)	−23.09 (51.93)	−2.637 (5.932)		9.738*** (2.491)	−3.798 (56.01)	−0.434 (6.395)
ln(GDP per capita)		−0.329*** (0.114)	−7.355*** (1.826)	−1.213*** (0.305)		−0.337*** (0.114)	−8.521*** (2.199)	−1.405*** (0.367)
Unemployment		−0.0324*** (0.0114)	0.116*** (0.0434)	0.0307** (0.0135)		−0.0304*** (0.0110)	0.125*** (0.0416)	0.0332** (0.0134)
ln(Population density)		−0.0991*** (0.0375)	−5.778*** (1.757)	−0.997*** (0.308)		−0.0894** (0.0374)	−5.174*** (1.670)	−0.893*** (0.293)
Urbanization		−0.698*** (0.0845)	−0.0369 (0.332)	−0.0331 (0.297)		−0.689*** (0.0800)	−0.0193 (0.333)	−0.0173 (0.298)
OECD group	1.240*** (0.0589)				1.240*** (0.0589)			

(*Continued*)

Table 5 (Continued).

Variables	ln(Infant Mortality)							
	Overall	**Endowments**	**Coefficients**	**Interaction**	**Overall**	**Endowments**	**Coefficients**	**Interaction**
Non-OECD group	3.217*** (0.0630)				3.217*** (0.0630)			
Difference	−1.977*** (0.0862)				−1.977*** (0.0862)			
Endowments	−2.224*** (0.236)				−2.237*** (0.305)			
Coefficients	−1.049 (1.340)				−2.509*** (0.943)			
Interaction	1.297 (1.362)				2.769*** (0.991)			
Constant			275.7* (160.0)				301.0* (154.7)	
Observations	198	198	198	198	198	198	198	198

Notes: Standard errors in parentheses, ***<0.01, **P<0.05, *P<0.1.

included instead of current health expenditure as a share of GDP, for either key performance indicator are qualitatively the same and are available in Supplementary Materials 4–6 for infant mortality, under-five mortality and healthy life expectancy, respectively.

Thus, not surprisingly, our estimates suggest that efficiency of healthcare systems, measured through any of the three indicators, is lower in our non-OECD sub-sample. These countries can achieve better outcomes by systematic improvement of direct and indirect factors through the respective policy measures.

Discussion

In line with the previous studies,[17,18] our results demonstrate that quality of governance and current health expenditure are indeed the main determinants of healthcare system performance in Asia. In addition, population density and urbanization are positively linked with healthy life expectancy in non-OECD Asian countries. In this group, unsafe water drinking negatively affects healthy life expectancy. Interestingly, our estimates suggest the presence of an optimal level of per capita carbohydrates consumption associated with healthy life expectancy. In the analyzed non-OECD Asian countries, unsafe water drinking and per capita carbon dioxide emissions increase infant mortality. In the OECD group, represented by Japan and South Korea, there is a strong negative association between per capita GDP and infant mortality in both sub-

samples, although its impact is far larger in the OECD group. In addition, unemployment is negatively associated with infant mortality there.

Since we focus our attention on Asian health systems, we need to track important differences in the historical legacy of OECD and non-OECD health systems in this vast region. Since 1949, and during the entire Cold War Era, most contemporary non-OECD Asian countries adopted Marxist-Leninist state theory routed health system establishments. All of them were essentially based on the legacy of the Soviet Semashko tradition, established in 1921.[27] It was largely focused on the principles of social justice and equity and obsessed with the goal to deliver as much affordable medical care as was possible, at the level of technology and social development, in the early Post-WWII decades.[28,29] The remaining socialist nations today in this region are China, North Korea, Vietnam, and Laos. In contrast, the typical free-market economies are Japan, India, Indonesia, Malaysia, Pakistan, the Philippines, the Republic of Korea, and Thailand. Japan was admitted to the OECD as early as of 1964 only four years after its establishment, while South Korea got its membership only in 1996.[30] These health systems faceted alongside Western European Bismarck and Beveridge traditions and the North American influence. Market mechanisms of supply and demand, although with a strict state regulation, allowed Japan to achieve a welfare state status in the early 1960s. "Asian Tigers" – the economies of South

Table 6 Oaxaca-Blinder Decomposition of Under-Five Mortality in Nine Asian Countries: Log-Linear Estimates with CHE as a Share of GDP

Variables	ln(Under-Five Mortality)							
	Overall	Endowments	Coefficients	Interaction	Overall	Endowments	Coefficients	Interaction
CHE as a share of GDP		−0.197 (0.370)	0.500 (0.523)	0.532 (0.558)		−0.0705 (0.326)	0.426 (0.504)	0.453 (0.538)
Regulatory quality [1; 6]		−0.200 (0.191)	0.798 (0.604)	0.459 (0.348)				
Regulatory quality*CHE/GDP		0.652 (0.792)	−0.496 (0.409)	−1.146 (0.949)				
Control of corruption [1; 6]						−0.107 (0.224)	0.313 (0.496)	0.239 (0.379)
Control of corruption*CHE/GDP						0.449 (0.833)	−0.332 (0.354)	−0.910 (0.974)
ln(Unsafe water drinking)		−1.143*** (0.118)	−3.547** (1.768)	2.587** (1.291)		−1.116*** (0.124)	−4.935*** (1.368)	3.600*** (1.000)
ln(CO_2 per capita)		−0.430*** (0.110)	0.364 (0.251)	0.781 (0.535)		−0.440*** (0.111)	0.660*** (0.188)	1.415*** (0.389)
ln(Animal protein consum. pc)		2.757*** (0.878)	34.92 (42.35)	5.445 (6.612)		2.911*** (0.969)	46.19 (39.93)	7.203 (6.242)
ln(Animal protein consum. pc)Sq		−2.963*** (0.997)	−14.80 (18.97)	−4.801 (6.160)		−3.123*** (1.096)	−19.66 (17.94)	−6.379 (5.832)
ln(Plant protein consum. pc)		2.242** (1.043)	318.6 (250.7)	6.265 (5.122)		2.534** (1.123)	437.4* (265.6)	8.602 (5.560)
(ln(Plant protein consum. pc))Sq		−2.180** (1.033)	−151.2 (121.0)	−5.893 (4.904)		−2.461** (1.110)	−208.1 (128.1)	−8.112 (5.323)
ln(Carbohydrates consum. pc)		0.999 (1.135)	−991.2** (486.7)	−3.006 (2.751)		0.648 (0.928)	−1,135** (490.5)	−3.441 (3.045)
(ln(Carbohydrates consum. pc))Sq		−1.022 (1.149)	492.3** (241.8)	3.031 (2.747)		−0.668 (0.943)	560.6** (243.5)	3.451 (3.026)
ln(Fat consumption pc)		−10.36*** (2.268)	80.82 (151.6)	4.544 (8.528)		−10.59*** (2.600)	91.40 (155.1)	5.139 (8.729)
(ln(Fat consumption pc))Sq		10.75*** (2.359)	−45.81 (71.72)	−5.231 (8.198)		10.97*** (2.693)	−51.30 (73.76)	−5.857 (8.432)
ln(GDP per capita)		−0.450*** (0.124)	−7.241*** (2.510)	−1.194*** (0.417)		−0.455*** (0.123)	−9.617*** (2.919)	−1.585*** (0.486)
Unemployment		−0.0363*** (0.0125)	0.127** (0.0538)	0.0339** (0.0163)		−0.0342*** (0.0121)	0.126** (0.0497)	0.0336** (0.0153)
ln(Population density)		−0.0590 (0.0401)	−6.376** (2.484)	−1.101** (0.433)		−0.0495 (0.0400)	−6.457*** (2.250)	−1.115*** (0.393)
Urbanization		−0.657*** (0.0904)	−0.193 (0.463)	−0.173 (0.414)		−0.655*** (0.0855)	−0.0468 (0.444)	−0.0419 (0.398)
OECD group	1.476*** (0.0512)				1.476*** (0.0512)			

(Continued)

Table 6 (Continued).

Variables	ln(Under-Five Mortality)							
	Overall	Endowments	Coefficients	Interaction	Overall	Endowments	Coefficients	Interaction
Non-OECD group	3.424*** (0.0662)				3.424*** (0.0662)			
Difference	−1.948*** (0.0836)				−1.948*** (0.0836)			
Endowments	−2.294*** (0.254)				−2.253*** (0.329)			
Coefficients	−0.789 (1.898)				−2.390* (1.270)			
Interaction	1.135 (1.915)				2.694** (1.312)			
Constant			291.7 (193.6)				295.7 (183.5)	
Observations	198	198	198	198	198	198	198	198

Notes: Standard errors in parentheses, ***<0.01; **P<0.05, *P<0.1.

Korea, Singapore and Taiwan – followed these footsteps during the late 1980s and early 1990s.[31] This has reflected the adoption of health economics principles in resource allocation and governance among the non-OECD, free-market economies. Historically speaking, these development milestones are visible in the order of mushrooming of Health Technology Assessment agencies (HTA) across the Far East.[32,33] Unlike the rest, the huge South Asian nations of India and Pakistan, so far, have not managed to establish a prosperous welfare statehood with a substantial degree of income and living standard equality for large swaths of population.[34] The blossoming economy of India, which currently demonstrates the fastest real GDP growth among large nations worldwide, exposes huge inequalities as reported via Gini indices in numerous studies.[35–37]

Population density and urbanization were positively associated with healthy life expectancy in non-OECD Asian countries. This may be largely attributable to the strong network coverage of healthcare institutions in core urban coastal areas and large industrial cities scattered across mainland China and Indochinese nations.[38] This effect is further visible in improved access to medical care and its affordability. Thus, a constellation of citizens in densely populated areas, regardless of few major setbacks, such as environmental pollution, has had prevailingly positive effects on longevity.[39] An elevation of lower social layers from the poverty in China and many

of these countries has contributed to these successes. The Chinese breakthrough achievement of lifting up to 800 million people from the poverty as documented by the respective UNDP,[40] UN[41] reports on sustainable Millennium Development Goals (MDGs),[42] and National Strategy documents,[43,44] was an important social policy model for less rich non-OECD surrounding nations facing similar challenges. Surprisingly, even Japanese average life expectancy in the early Post-WWII period was barely 55 years as an example among Asian OECD nations.[45] Japanese Imperial legacy of strong industrial development was the pioneering case in this vast Asian region, historically dating back from the Meiji reformation of 1868 and culminating in the early 1900s.[46–48] With the introduction of meat into diet, improved housing, heating systems and a variety of public health measures, life expectancy was rapidly increasing during the following decades. Nowadays, this success story is repeated on a much larger scale in Asia.[49]

In this group, unsafe water drinking has a statistically negative effect on healthy life expectancy. As noted earlier, environmental pollution, particularly in coastal industrialized mega-cities has become a brand feature of rapid development of a scale.[50] Theoretically, it can be explained it with the fact that many effectively dirty technologies were moved from the rich OECD nations to China, and, later on, India,[51] Vietnam, Malaysia,

Table 7 Oaxaca-Blinder Decomposition of Healthy Life Expectancy in Nine Asian Countries: Log-Linear Estimates with CHE as a Share of GDP

Variables	ln(Healthy Life Expectancy)							
	Overall	Endowments	Coefficients	Interaction	Overall	Endowments	Coefficients	Interaction
CHE as a share of GDP		0.0531 (0.0414)	−0.0479 (0.0438)	−0.0510 (0.0468)		0.0699* (0.0357)	−0.0823** (0.0392)	−0.0875** (0.0424)
Regulatory quality [1; 6]		0.0124 (0.0212)	−0.0180 (0.0455)	−0.0103 (0.0262)				
Regulatory quality*CHE/GDP		−0.0102 (0.0878)	0.00633 (0.0398)	0.0146 (0.0919)				
Control of corruption [1; 6]						0.0404* (0.0243)	−0.0560 (0.0380)	−0.0428 (0.0292)
Control of corruption*CHE/GDP						−0.0678 (0.0901)	0.0326 (0.0342)	0.0894 (0.0940)
ln(Unsafe water drinking)		0.0956*** (0.0130)	0.382*** (0.0946)	−0.279*** (0.0692)		0.106*** (0.0133)	0.439*** (0.0739)	−0.320*** (0.0542)
ln(CO_2 per capita)		0.149*** (0.0135)	−0.0822*** (0.0158)	−0.176*** (0.0309)		0.142*** (0.0133)	−0.0885*** (0.0131)	−0.190*** (0.0240)
ln(Animal protein consum. pc)		−0.0602 (0.0959)	−4.585** (2.295)	−0.715** (0.360)		0.0635 (0.103)	−5.610*** (2.176)	−0.875** (0.343)
ln(Animal protein consum. pc)Sq		0.0480 (0.109)	2.053** (1.042)	0.666* (0.340)		−0.0869 (0.117)	2.565*** (0.994)	0.832** (0.326)
ln(Plant protein consum. pc)		−0.110 (0.105)	−49.75*** (13.97)	−0.978*** (0.350)		0.0162 (0.105)	−66.47*** (14.71)	−1.307*** (0.410)
(ln(Plant protein consum. pc))Sq		0.0977 (0.103)	24.22*** (6.769)	0.944*** (0.340)		−0.0265 (0.104)	32.37*** (7.122)	1.262*** (0.399)
ln(Carbohydrates consum. pc)		0.126 (0.134)	33.42 (37.13)	0.101 (0.137)		0.0937 (0.111)	63.43* (35.44)	0.192 (0.183)
(ln(Carbohydrates consum. pc))Sq		−0.126 (0.134)	−16.65 (18.51)	−0.103 (0.138)		−0.0929 (0.111)	−31.54* (17.66)	−0.194 (0.184)
ln(Fat consumption pc)		1.024*** (0.249)	−2.995 (8.813)	−0.168 (0.496)		0.646** (0.273)	0.0523 (9.159)	0.00294 (0.515)
(ln(Fat consumption pc))Sq		−1.014*** (0.258)	1.612 (4.234)	0.184 (0.484)		−0.628** (0.282)	−0.0321 (4.422)	−0.00366 (0.505)
ln(GDP per capita)		−0.0699*** (0.0139)	1.616*** (0.151)	0.266*** (0.0272)		−0.0739*** (0.0135)	1.885*** (0.169)	0.311*** (0.0307)
Unemployment		0.00321** (0.00127)	−0.00822* (0.00442)	−0.00219* (0.00128)		0.00287** (0.00119)	−0.00643 (0.00415)	−0.00171 (0.00117)
ln(Population density)		0.0660*** (0.00581)	0.0422 (0.133)	0.00728 (0.0229)		0.0629*** (0.00560)	0.118 (0.120)	0.0203 (0.0208)
Urbanization		0.0118 (0.00980)	−0.0281 (0.0262)	−0.0251 (0.0235)		0.0162* (0.00899)	−0.0312 (0.0249)	−0.0279 (0.0223)
OECD group	4.272*** (0.00501)				4.272*** (0.00501)			

(Continued)

Table 7 (Continued).

Variables	ln(Healthy Life Expectancy)							
	Overall	**Endowments**	**Coefficients**	**Interaction**	**Overall**	**Endowments**	**Coefficients**	**Interaction**
Non-OECD group	4.108*** (0.00593)				4.108*** (0.00593)			
Difference	0.164*** (0.00776)				0.164*** (0.00776)			
Endowments	0.297*** (0.0278)				0.283*** (0.0352)			
Coefficients	0.191* (0.100)				0.221*** (0.0674)			
Interaction	−0.324*** (0.104)				−0.340*** (0.0760)			
Constant			11.00 (16.96)				3.237 (15.78)	
Observations	198	198	198	198	198	198	198	198

Notes: Standard errors in parentheses, ***<0.01; **P<0.05; *P<0.1.

Indonesia, Thailand and other surrounding nations. Water scarcity, given the fact that the major bulk of the human population lives in this large region, is gradually becoming an issue of strategic importance.[52] This refers particularly to the scarcity of drinking water supplies. Currently, there is less shortage of the technical water for building and industrial needs. Our study confirms substantially higher per capita carbon dioxide emissions in the Republic of Korea and Japan. This phenomenon might be largely attributable to the living standards, volume of household consumption and traffic density in relation to the population size.[53] Many countries in the Middle Eastern region of Asia, together with Australian regions, alike, have already imposed control policies over citizens' water consumption.[54] Yet, most of Southeast Asia remains blessed with monsoon rains with some notable exceptions surrounding the huge Gobi desert – China, Mongolia, and Central Asian countries.[55] These regions are mostly outside our current consideration, but remain loosely tied to the economy of the vast area of Southeast Asia. This is heavily driven by the unfolding build-up of the huge New Silk Road or "One Road – One Belt" (OBOR) project, co-funded by the Asian Investment Bank, the BRICS Bank, and national governments.[56] Notably, the "Belt and Road" is commonly designated in Asia and the West alike, as the largest infrastructure investment project in the entire history of humanity.[57]

Interestingly, only per capita consumption of carbohydrates is significantly linked with healthy life expectancy. Nutrition is increasingly gaining attention in interdisciplinary sciences of health economics and policy alike, given its tremendous influence over contemporary lifestyle. Foods with high numbers of preservatives, allowing them to be stored in supermarket warehouses for up to two years were confirmed for their carcinogenicity and other chronic toxicity.[58] Next to this, high degrees of saturated fats and recycled oil are being consistently used in Asian cuisines, with a particularly strong presence in many authentic national cuisines across Chinese (typically Sichuan, Anhui, and Yunan), Korean and Vietnamese regions.[59] Correlation of the use of carbohydrates with healthy life expectancy is logical, given the fact that rice (*Oryza glaberrima* or *Oryza sativa*) and sweet potato (*Ipomoea batatas)* play a central role in the diet of all these nations. Other regional cuisines, eg, the Thai, own their seductive reputation largely to the addition of simple sugars in a variety of meat, fruits, and vegetable-based meals.[60] The WHO has recently formally acknowledged saccharose as an addictive substance and recommended its abolishment in the institutional nutrition of children in kindergartens' and schools' kitchens.[61] This is being complemented with large quantities of wheat made pasta, among which traditional Japanese Soba is among the most famous ones.[62] This means that huge quantities of complex

carbohydrates, also known as polysaccharides, like starches, are being used as a base compound of any meal in Asian societies.[63] Given the contemporary daily routines in high-income OECD societies, it appears that in Asian societies the presence of starches plays a far more important dietary role.[64] This short insight into the habitual ways of life and nutrition patterns gives us an explanation for our findings, supported by the seminal studies.[65]

Among non-OECD Asian countries, unsafe water drinking and per capita carbon dioxide emissions increase the infant mortality rate. Early childhood survival, proxied by under-five mortality as a long-term trend, continues to improve radically all across the region.[66] The pace of these positive developments is, of course, much slower in lower income societies like Myanmar, Nepal, Bangladesh, rural regions of India, Pakistan and Indonesia, which contribute greatly to early childhood mortality across the region.[67] Yet, one should understand that unsafe water drinking remains directly correlated to both infectious juvenile diarrhea syndromes[68] and heavy metal toxicities.[69] There is an abundance of academic literature on complex causal relationship between economic growth and human survival.[70] In our observation of the nationwide aggregate data, we have observed a strong negative association between GDP per capita and infant mortality as well as under-five mortality in both sub-samples, although its impact is far larger in Japan and the Republic of Korea.[71] This means that the richest of these societies achieve much more favorable early childhood survival.[72] In contrast, low- and middle-income countries among them have a lower capacity for resource allocation in preventive childhood medical care.[28] Vaccination coverage, neonatal intensive care unit accessibility, midwife nursing staff density, sanitary and dietary conditions for post-delivery conditions and maternal care are obviously very heterogeneous across the region.[73]

Among the limitations of this study, we should mention that data on sufficient physical activity were not included in the analysis because the WHO did not satisfy our data request.[19] Further research should benefit from considering the impact of this important factor, which directly affects human health. In addition, statistical analysis would benefit from including recent data when it becomes available. Nevertheless, we hope that these findings might facilitate further comparative research on the effectiveness of leading Asian health systems.

In addition, the multicollinearity problem was not solved completely due to either control variables, or powers, products of our independent variables, or year- and country-dummy variables. However, as Allison[74] suggests:

> Regardless of your criterion for what constitutes a high VIF, there are at least three situations in which a high VIF is not a problem and can be safely ignored: 1. The variables with high VIFs are control variables, and the variables of interest do not have high VIFs. [...] 2. The high VIFs are caused by the inclusion of powers or products of other variables. [...] 3. The variables with high VIFs are indicator (dummy) variables that represent a categorical variable with three or more categories.

All three cases mentioned above are presented in our model. Following the usual practice of addressing the multicollinearity problem, we excluded, in various combinations, variables with high VIFs. Predictably, this led to violations of other assumptions, namely, model specification problem, functional form problem, influential observation problem, residuals' normality problem, or heteroskedasticity problem.

Major policy implications of this study refer to the balance of input–output ratio of health care investment versus the population health outcomes achieved in various Asian nations with diverse national health policies in place. In the observed period, an array of political reforms affecting health sectors took place. Among many notable improvements are increased physician and nursing staff density and extensive development of a rural network of primary and outpatient medical care facilities across their vast rural peripheries. An additional milestone is International Health Technology Assessment (HTAi), resulting in the establishment of national Health Technology Assessment (HTA) agencies with South Korea on the lead, followed by Taiwan, Singapore, China, Japan, and Thailand. Concerning growth of citizen out-of-pocket (OOP) spending alongside the deepening gap between the newly established rich elites and middle-income citizens presents a serious obstacle towards achieving universal health coverage. Thus, the major policy implication of our study is that most of Asian national authorities should keep in mind their control of OOP private expenditure via an array of risk-sharing agreements. Room for exit strategies to decrease huge budgetary pressures was already recognized in such negotiations among Big Pharma multinationals and governmental authorities in charge of marketing approval of expensive innovative medicines, such as Chinese CFDA and

Japanese PMDA. Additional strong policy implication of our study, for Japanese policy-makers in particular, is in their almost unbearable approaching burden of accelerated population aging, seriously questioning the financial sustainability of entire social, retirement, and health insurance funds. Thus, we frankly hope that insights provided with these econometric and population health estimates could help local authorities to derive a clearer transnational understanding of their joint and shared challenges and risks approaching during the 2020s.

Conclusion

Our goal was to assess the effectiveness of healthcare spending among these nine Asian nations over the period 1996–2017. Throughout the complex two-way fixed effects model, based on aggregate national datasets, we managed to reveal some of the hidden underlying drivers of health sectors evolving change in Asia. It became apparent that major performance indicators of the national health system included population density, degree of urbanization, nutrition structure and dietary patterns, unemployment and the availability of clean, safe water for citizens' everyday needs.

Japan has generally outperformed other countries from the sample in major healthcare performance indicators[75] like healthy life expectancy and infant mortality, while the Republic of Korea is ranked second. The only exception is per capita carbon dioxide emissions, which have maximal values in the Republic of Korea and Japan. Non-OECD nations' outcomes were led by China as the largest economy. In terms of the declared UN Sustainable Millennium Goals, China was designated as a classical case of over-achiever by the WHO reports. Thus, it may be regarded as a success story with few structural elements of its health policies[76] being applicable to some surrounding nations and the UN Sustainable Millennium Goals overachiever.[10] This group was characterized with a substantial improvement in the efficiency of health spending since the middle of the 1990s. Yet, progress was noted with remarkable heterogeneity within the group. In the few decades long horizon, observation of these core developments within Asia has exposed rapid growth and appearance of sustainable health system capacities. Their pace of improvement in human longevity, early childhood survival, physician density and affordability of medical care might be regarded a positive exemplary case for most of LMICs worldwide.

Ethical Statement

This study has been conducted with the anonymous, national-level aggregate data thus no patient interventions neither private data protection issues where involved. According to the Helsinki declaration, such study design does not require prior IRB/Ethical Committee consideration neither its approval.

Disclosure

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