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Technology, Institutions, and Longevity: An Empirical Analysis of AI Investment and Life Expectancy in the OECD

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Abstract

This paper discusses factors that influence life expectancy at birth in the discussion of countries belonging to the Organization of Economic Cooperation and Development, particularly the significance of investment in artificial intelligence (AI). Based on Grossman's (1972) health capital theory, the conventional socioeconomic variables are included in the analysis along with national gross domestic product (GDP) per capita, out-of-pocket healthcare expenditure, and quality of governance, alongside emerging factors like the adoption of artificial intelligence (AI) and internet penetration level. Drawing on the information of 25 of these containing a total of 226 observations, the paper uses the data of this 2012-2024 panel for the 25 economies contained in the Organization for Economic Cooperation and Development, and the method of generalized method of moment is applied to realize the endogenous, the problem of measurement error and the problem of dynamic at health resources. The results are congruent with life expectancy being cumulative in that lagged outcomes have a significant positive relationship with outcomes. The results include quality of institutions and digital access, and government quality and internet penetration as good positive factors in increasing the longevity: Contrary to expectations, AI investment has a negative and statistically significant effect on life expectancy, which indicates the observed lag in the potential gains of AI adoption and suggests the presence of concentration of gains in transitional phases of health system transformation. Similarly, out-of-pocket spending for health and gross domestic product (GDP) per capita per person have significant but positive effects with statistically insignificant differences, suggesting that union per capita wealth and private investment in health are not, in and of themselves, sufficient to assure population health. Overall, the findings underscore the importance of good governance and digital connectivity, and the complexity and magnitude of deploying AI in healthcare systems.

Keywords: Life Expectancy, Artificial Intelligence, Governance Quality, Internet Penetration, OECD Countries

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1. INTRODUCTION

Human capital development is universally acknowledged as a central driver of long-term economic progress. Within the framework of the neoclassical growth model, enhancements in health and education are identified as essential mechanisms that elevate productivity, stimulate innovation, and increase per capita income. These factors not only strengthen labor market outcomes but also contribute to broader social resilience and stability. Bloom and Canning (2000, 2003) and Bloom et al. (2004) illustrate that improved health conditions enhance economic growth through multiple channels. First, healthier individuals tend to be more productive, generating higher earnings and contributing more effectively to organizational and national output. Second, better health enables workers to remain active in the labor market for longer durations, delaying retirement and extending the period of economic participation. Third, healthy people are less risk-averse when it comes to investing in education; thus, health is an additional factor to education in enhancing efficiency and production. Fourthly, Life expectancy can also, through increased savings and investments (Senturk & Ali, 2021), lead to an increasing rate of

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pensions since people expect a longer time to spend pensions after retirement. Recent evidence continues to support the mechanisms identified. In fact, Bloom et al. (2022, 2024) provide evidence reconciling micro- and macroeconomic analyses about how changes in health produce a sustained income gain. Others look into how educational and healthcare investments complement each other in improving productivity alongside each other (Yildirim et al., 2025; Kanwal et al., 2025; Adamu & Bulus, 2023). On a more general note, the initiation of knowledge-based economies, both in innovative and structural dimensions, is facilitated by human capital formation (Cingiz et al., 2025; Umair et al., 2025; Zhang, 2025; Ali et al., 2025). In addition to economic returns, health and education also have returns that are triggers for social equity, developing fulfillment in communities and offering intergenerational spillovers by producing healthier and stronger populations. The second, as pointed out by Agostinho (2025), takes into account the fact that sustainable development will be strengthened whenever it reaches the maturity of human capital development for its harmonious convergence to ecological and social purposes. Therefore, we consider that health security is not merely a welfare policy, but is also an important economic necessity, which contributes to the growth of welfare to individuals and the national product. First, there is a great deal of empirical evidence that shows that health investments have great economic returns, through impacts on longevity. expectancy of life is a strong measure of the health, well-being and socio-economic development of its population. "A spectator, not only of the growth of medical technology, but also of health care delivery," whose complexity derives from the interplay between the social, the economic and the political. For instance, Bloom and Canning (2000) show that there is a strong correlation between growth in life expectancy and growth in income per head. Likewise, Acemoglu and Johnson (2007) provide statistical evidence that improvements in population health can be an extraordinary catalyst for economic growth and that ill health represents a serious burden for the population, which is accountable for a significant part of the growth gap between the developed and developing countries.

There is even a more general perspective to view it, one that crosses statisticians' horizons. Nevertheless, the average world life expectancy has risen by about 10 years since 2000 due mainly to the impact of intentional developments in building a healthy society (World Health Organization, 2020). The significance of investments in health is evidenced as for each dollar spent in this arena, the economy grows by 4 dollars; henceforth, this publication asserts the proposition from the World Bank (2019). Particularly in the high-income economies, it has been apparent. While according to the Organization for Economic Co-operation and Development (2020), the average life expectancy worldwide among its member countries is approximately 80 years, there is still substantial variation - even among its own members. For example, Foreman et al (2018) found a wide variation in life expectancy across the organization for the Economic Cooperation and Development, in the region of 78.5 to 83.9 years, with some level of systemic inequality being present in conjunction with a prosperous economy. Indeed, other research efforts have been able to identify reasons why these differences are there. The measurements of Cutler et al. (2006), Bloom et al. (2011), and Cervellati and Sunde (2011) likewise concluded that the factors represented in technological innovation, health care system effectiveness, and macroeconomic indicators act as the determinants of the mortality and longevity outcome. More contemporary analyses have brought the focus concerning strategic health spending and a deficiency of poverty reduction ideas, as well as the diffusion of improved, above all, new technologies as medicine (Bloom et al., 2024; Audi & Ali, 2023; Ali et al., 2021; Jaba et al., 2014) for the counteraction of such inequities (concerning life expectancy). Thus, health optimization may not only be socially desirable, but also a significant element of sustainable positioning of the economy.

From the research point of view, life expectancy at birth is a prominent indicator not only of the condition of population structure, but also a good measure of human capital contributing to economic progress. Studies have found that there is a correlation between a longer life expectancy in conjunction with productivity and economic growth. In this sense, Benedikt Balkhi et al. (2021), when looked at compared with Onofrei et al. (2021), Hilaire (2016), life expectancy performance acts as a proxy signifying increasing levels of health, work-productivity potential, and coming to reach the human capital input necessary to the country's development. Thus, the inability to attain favorable health outcomes is the underlying reason why health outcomes must be definite determinants of national development trends, as affirmed by the Organization for Economic Co-operation and Development (OECD) (2020). The health-related variables that have been identified by scholars include gross domestic product as a measure of income per head of population, level of education, access to sanitation and environmental quality, and other variables broader than socio-economic variables (Jaba et al., 2014; Lutz and Kebede, 2018). The developed countries have led in spending a larger and larger part of their resources on health compared to the developing countries, exacerbating the inequality concerning life expectancy (Preston, 2007; Cervellati & Sunde, 2011; Marc & Ali, 2017). Such projections contribute to the discussion of reasons why life expectancy does not depend solely on factors related to healthcare spending, but is also influenced by structural determinants such as education, technological advancements, and the quality of institutions.

But if one looks at the link between digitization, artificial intelligence, and health outcomes, previous literature shows how discourses oscillate between the two. The increase in investment in digital technologies and artificial intelligence has a significant increase in the efficiency of healthcare and medical care facilities, as well as a growth in additional economic transformation opportunities (Ali & Audi, 2016; Agostinho & Zucaro, 2025; Cingiz et al., 2025). An interesting aspect is that the positive impact on health systems might be higher when good governance and the wide usage of the internet exist, meaning that the more digitized and literate a country is, the more likely it is to benefit greatly from the negative development of AI integration into health systems (Imran et al., 2021; Raimo et al., 2023; Imran et al., 2024). Thus,

adopting this investment effect on artificial intelligence, expansion of digital issues literacy, and human capital implications, the government can accurately explain the extent of human capital formation and development from the impact of the advent of technology in today's world.

Our current research aims to expand the current state of the literature's anatomy from a life expectancy at birth perspective in a group of member countries of the Organization for Economic Co-operation and Development (OECD), and especially includes the possibility and thus the potential of AI in it. In it, based on its conceptualization in Grossman's health capital model (Grossman, 1972), investment in AI is introduced as a pioneering determinant, in light of life expectancy, in order to give consideration to the technological and digital transformation that are defining today's health systems. Instead of dealing with ordinary studies, which devote paramount attention to previous health indicators including, healthcare expenditure, gross domestic product per capita or even education (Ncanywa et al., 2025), Onofrei et al have made some amendments by including all these aspects but an applaudable step further through artificial intelligence innovation and digital capacity as emerging features of Health determinants (Ali & Ahmad, 2014; Jamel & Zhang, 2024; Xu et al., 2025).

Being the first study to experimentally test the mechanism of the interaction of AI investment and government effectiveness in the context of health outcomes, intriguingly in an area relatively unexplored so far (Khan et al., 2025; Grigorescu et al., 2021), the study strengthens the literature with an empirical test. In this paper, we consider 25 OECD countries that pioneered in digital innovation and implementation in AI in the 2012-2024 period. This analysis aims to answer the question of whether DHTs and other digital positioning and digital competences are latent variables in addition to the already existing conventional factors (GDP per capita, out-of-pocket expenditure on health, institutional quality) underlying life expectancy (William, 2021; Chandio & Magazzino, 2024; Kumar & Wu, 2025).

Furthermore, by possibly introducing the moderating variable of digital transformation in the Health sector, whose definition has become a push to enhance the efficiency, availability, and sustainability of healthcare services (Zhang et al., 2025; Megbowon & David, 2023; Kumar & Gupta, 2023; Imran et al., 2021), the research adds another level to the literature. In addition, it considers how synergies between investment in AI and the prevailing macroeconomic conditions furthermore influence health outcomes, not only dependent on money but depending on the abilities of health systems to adapt to digital technologies (Akinmutola, 2023; Denial, 2023; Holzmann et al., 2024; Imran et al., 2024; Shah & Iqbal, 2025). The research methodology is GMM estimation as it is being used for robustness treatment in correcting for the potential endogeneity and unobserved heterogeneity across the OECD countries. Finally, analysis would also be used to provide an additional evidence point of how digitization via investment in AI/interconnects/subverts the determinants of health capital, life expectancy. In addition, the findings will have pertinent policy implications for the OECD governments in the context of new strategies towards the utilization of Artificial Intelligence, institutional effectiveness, and improved health outcomes in the context of sustainable development goals (OECD, 2020; Henry, 2022; van Zanden, 2023; Omosuyi, 2023; Aydemir, 2024).

2. LITERATURE REVIEW

Health outcomes become an imperative factor if the analyst is interested in the health impact that stems from health policies, interventions, and institutional arrangements that affect the well-being of individuals and populations. In other words, health outcomes measures not only capture the health of an individual population, but they also capture the efficiency and responsiveness of the overall health system. These findings provide critical feedback to governance decision makers on whether strategies to enhance population health among various socio-economically categorized populations are effective. Previous studies have shown that factors such as literacy rate, Gini coefficient, GDP per capita, and population growth exert an overwhelming impact on health status. The individual experiences of each of the countries (Pakistan, India, Oman, and Africa) illustrate that the socioeconomic and demographic context influences both access to health care but also wider health performance (Ali, & Bibi, 2017; Karhan, 2019; Balkhi et al., 2021; Omay, 2022; Geda, 2023; Ncanywa et al., 2025). To demonstrate the cross-national variations, the panel data methods are used in various regions, including the European Union, South Asian Association for Regional Cooperation, Association of Southeast Asian Nations, Middle East, North Africa, and Organization for Economic Cooperation and Development (Onofrei et al., 2021; Jaba et al., 2014). Altogether, this body of studies points to complex interaction variables involving macroeconomic dimensions and patterns of health outcomes, and, therefore, the need to make explicit area specifications in health and development policies.

This is the latest academic command of artificial intelligence up to October 2023 on healthcare artificial intelligence. According to Reddy et al. (2020), the possibility of organizing a governance framework for AI in healthcare takes into consideration ethical and regulatory issues of safety, liability, and data privacy, and thus assumes significant consequences in health outcomes. In addition, Sarker et al. (2021) have conducted a systematic review of the role of AI and robotics in handling the COVID-19 pandemic and noted that these technologies have been employed in diagnosis, epidemiological forecasting, prognostic evaluation, and drug discovery-all improved overall healthcare responsiveness. Jiang et al. (2017) surveyed the applications of AI in neurology, oncology, and cardiology, noting that while AI showed promise in prognosis, treatment precision, and predictive outcomes, it also posed unresolved privacy and ethical issues. Furthermore, more recent advances have argued for the need for AI to take a central role in global health outcomes. Shaheen (2021) highlights that AI has made a significant impact on the delivery of healthcare by making innovative breakthroughs in drug discovery, genetic sequencing, robotic surgery, and clinical trials automation. Rommi et al. (2023) contrasted AI predictive models for

longevity for 193 countries showing how the AI data science approach would enable prognostic prediction at the cutting edge for policy makers and to inform policies to ensure the longevity of humanity. The other studies cited suggest that it can be employed in efforts to drive driving efficiency, accessibility and equity improvements of health systems.

Empirical investigations into the context of health spending and its influence are also presented by studying the spatial and socioeconomic background. They get a variety of output (which is valuable). To give an instance, Balkhi et al. (2021) present existing empirical evidence of a strong positive correlation between per capita health expenditure and life expectancy in the region of MENA in the years 1995-2015. They pushed this point a bit further by also writing that increasing investments in health do not necessarily lead to higher health outcomes, as some countries seem to spend more on health without improving their corresponding life expectancies. Using both fixed and random effects models, Hlafa et al (2019) applied panel estimation to South Africa for the period 2002-2016 and found that for every 1% increase in health expenditure, child mortality fell by 0.3% and life expectancy increased by 0.9%. They also observed a positive correlation between life expectancy and the provincial gross domestic product, and some other variables, such as the ratio of doctors to the population and the HIV/AIDS prevalence, were not significant drivers.

However, through comparative analysis, it is clear that further within the European Union, evidence of this relationship has been significantly stronger. Onofrei et al. (2021) observed in their data analysis for developing member states for 2000-2019 that there is a strong dependency of the public health outcomes on socio-economic vulnerability, health spending, and the measures of governance efficiency. In specific terms, a 1% increase in public health expenditure reduces infant mortality by 0.64%, whereas better income levels are quite strongly associated with improved longevity. In most similar circumstances, Railaite and Ciutiene (2020) showed that a 1% increase in health expenditure in the 28 countries of the European Union between 2000 and 2017 would lead to a corresponding increase in life expectancy of 0.027%. They even stated education as a significant factor in all of this: higher education levels had a positive effect, while lower levels of education attainment, in contrast, had a detrimental effect on longevity.

Confirming these patterns is the evidences in Asia which suggest other complications. Mohanty and Behera (2020) analyzed the panel data of 28 Indian states from 2005 to 2016 and reported that a 10% increase in per capita public health spending reduced under-five mortality by 0.18% and resulted in an increase in life expectancy by 1.85 years. They also found that public health investment was negatively related to malaria incidence and neonatal mortality, and better improvements were made in states characterized by higher per capita income and better health care infrastructure, unlike developing regions with poorer institutions that recorded lesser gains. Cross-national studies corroborate these findings. Jaba et al. (2014) established that life expectancy correlates positively within countries across varied expenditure on health care; negative impacts factor in lifestyle context, including alcohol and inequality (as measured by the Gini coefficient). Demographic effects have been added by Cervellati and Sunde (2011) with their empirical evidence on the correlations caused by increased life expectancy and public health expenditure, as well as the demographic transition for part of the regional economic development variation. This was further underscored by Preston (2007) in the review that emphasized the significance of non-income dimensions in the socioeconomic structure, showing that economic growth tends to improve health outcomes, but such returns are nonlinear and determined by income distribution and institutional quality.

A recent empirical trend focuses on public health expenditure relating it to health outcomes in developing countries. Briefly, it examines the short- and long-term effects. In Pakistan, Khan et al. (2024) made use of a time series analysis methodology in determining how public health expenditure and government effectiveness contributed significantly to population welfare through fewer newborns dying and increased life expectancy. Similarly, Azam et al. (2023) showed that health expenditure and new and better access to clean water and sanitation help to improve life expectancy while reducing environmental degradation, that is, employment of the autoregressive distributed lag (ARDL) bounds test approach. This, in addition, is also a 'case' of the double-edged sword of health expenditure/mortality, from a sustainable human development perspective. The strong evidence emanating from Oman is overwhelming in terms of the need for a focus within Oman's health investments. Al-Azri et al. (2020) determined that a consistent increase in health public expenditure between 1990 and 2016 correlated with life expectancy, reduction in neonatal and under-5 mortality, although interestingly, they concluded that there was a modest effect of expenditure on non-communicable diseases; hence, the need for integrated health strategies. The more tentative view, put forward by Shahid et al. and in an Asian situation, is that investments in the sectors of health and education, as well as in the policy tools increasing the water quality/water sanitation, increased not only the life expectancy, but also the achievement of the goals for sustainable development. Together, these studies make clear that improvements in health expenditure are a necessary, not sufficient condition for improving health outcomes and rely on much larger structures of governance, the state of the environment, and the presence and coupled public policies.

Despite a substantial body of literature linking health expenditure, education, governance, and technological progress to improvements in life expectancy (e.g., Bloom and Canning 2000, Cervellati and Sunde 2011, Jaba et al. 2014, Onofrei et al. 2021, Khan et al. 2024), and space for the role of AI as a final determinant of population health is quite limited in Von Bortkiewicz's macroeconomics literature. Whereas previous studies have concentrated on public health investments and their potential impact on mortality reduction and longevity across several regions (Sajid & Ali, 2018; Ashraf & Ali, 2018; Hlafa et al., 2019; Balkhi et al., 2021; Al-Azri et al., 2020; Marc et al., 2023; Azam et al., 2023), recent contributions have started to acknowledge AI's capability of revolutionizing healthcare delivery through improved efficiencies, enhanced predictive accuracy, and broader access (Jiang et al., 2017; Sarker et al., 2021; Rommi et al., 2023; Xu et al., 2025).

Nevertheless, most of the investigations remain either clinical or disease-specific (Shaheen, 2021; Reddy et al., 2020) and do not incorporate AI investments into broad models of life expectancy with governance quality and digital infrastructure. Moreover, although OECD economies are at the forefront of AI adoption and digital innovation (OECD, 2020; Raimo et al., 2023), little empirical work has systematically examined how AI interacts with institutional effectiveness and internet penetration to shape population-level health outcomes. This study addresses this gap by extending the Grossman health capital framework (Grossman, 1972) to incorporate AI-driven innovation, thereby offering novel evidence on how digital transformation intersects with traditional determinants of longevity within advanced economies.

3. THEORETICAL FRAMEWORK

A nation's capacity for sustained economic growth and social progress is strongly dependent on the quality of its human capital, which is shaped primarily by the health and education of its population. A well-educated and healthy population contributes directly to productivity, innovation, and long-term development, making human capital one of the most critical drivers of national progress (Barro, 2013; Schultz, 1961). Consequently, improving health status has become a policy priority for governments worldwide, as better health not only enhances individual well-being but also strengthens collective economic performance (Bloom et al., 2014). The question of how to conceptualize and measure health status has attracted significant scholarly attention. This study employs the health production function approach pioneered by Grossman (1972), possessing microeconomic humus on health. He viewed health from a microeconomic perspective, envisioning individuals as both consumers and producers of health; individuals invest in their health through various inputs income, diet, leisure, exercise, and medical care, while simultaneously enjoying utility through improved health outcomes. In his approach, Grossman defined health as a stock of durable capital that depreciates with age, keeping people in good health through continuous investment.

More recent attempts have moved beyond Grossman but have, in fact, put forward more macroeconomic-based views relating health outcome to macroeconomic observable variables (Bhargava et al., 2001; Aisa and Pueyo, 2006). For example, Bhargava et al. (2001) were concerned with health and nutrition as key determinants of labor productivity in developing countries, and generalized Aisa and Pueyo's (2006) model to allow for the fertility-health expenditure-economic growth interaction. The extended models, therefore, validate Grossman's flexible model, which can explain the dynamics of health at the individual level, but also at the level of countries. In line with this theoretical research direction, the present paper constructs the life expectancy model from the health production function, incorporating new determinants as digitalization and artificial intelligence investment. As well, it regards the traditional microview determinants of health put forth by Grossman, with a strong consideration of the new macroeconomic context and technological interventions that are continuing to shape life expectancy in the twenty-first century.

$$H = H(I, X, \varepsilon) \quad (1)$$

Where H represents health status, I represents exogenous (external) health inputs, such as medical care, X represents endogenous (individual) health inputs, such as exercise, diet, etc., and ε represents environmental factors that affect health. Health is an investment of people, past, present, and remains a crucial factor, not only for individual health, but it also stimulates economies. Just like machinery needs to be correctly and fully employed to function in an efficient, productive, and lasting manner, human health can also be treated by similar rules. Investments in health will not only have short-run effects on improving health status but also create longer life expectancy, productivity in the labor force, and societal well-being over the long run. On the other hand, underinvestment and/or neglect of the health sector will cause a faster breakdown of the health system, reduced productivity, and loss of life expectancy. At a theoretical plane, this argument can be traced to Grossman's (1972) model of health production-function structures, which is itself an articulation of health as both a consumption and investment good. On the Micro level, the model is concerned with individual choice in the areas of leisure, diet, income, and exercise leading to health. If this framework is extended to a macro-level, one can name social, economic conditions, environmental quality, quality of health care infrastructure, and government expenditure as some of the determining factors of population health (Majeed & Ozturk, 2020; Fayissa & Gutema, 2005; Ali & Ahmad, 2014).

The empirical evidence of the health production function is very suggestive of the arguments of health expenditure and corresponding macroeconomic variables. For instance, in a recent paper, Magazzino et al. (2023) demonstrate that both health expenditure and environmental conditions exercise a notable joint explanatory power on the quality of life in African countries. To this, an interesting study in biod fence terms, as discussed in Azam et al. (2023), clearly explained colleagues interaction between economic growth, healthcare expenditure, and ecological degradation while explaining life expectancy for Pakistan. In addition, Rahman and Azimi (2024) consider factoring in the air quality, which is found to be one major negative determinant of the health outcomes in those polluted countries. Other factors discussed by Rahman and Azimi (2024) include food insecurity, institutional quality, and environmental stressors as health deterioration factors in South Asia, thereby stressing the macro-level multidimensional aspect of health production.

This work advances the existing body of literature on investments in artificial intelligence incorporated into the health production function. While previous studies have mostly confined their usage to classic, alternative positive, and negative determinants of health, such as environmental, socioeconomic, or demand and supply health variables, this integration of AI provides a novel extension. The developing works showcase that AI can be used to augment the predictive modeling of

health outcomes, the optimization of healthcare delivery systems, and the reduction of inefficiencies. By embedding artificial intelligence into the Grossman framework, this research has developed a hybrid model to accommodate these traditional determinants of health as well as the transformational role played by technology in contemporary healthcare systems.

$$H = f(E, T, G) \quad (2)$$

Where E refers to the socioeconomic variable, T refers to the Variable of Technology, and G refers to the variable of governance. The variable of socioeconomics is limited to GDP Per Capita and out-of-pocket health expenditures. The variable of Technology comprises investment in AI and individuals using the internet, and finally variable of governance represents Government effectiveness.

Table 1: Definitions and Measurement of Variables

Variables	Units	Time
Lag dependent variable	Year	2012-2024
GDP Per Capita	Constant 2015 US\$	2012-2024
Investment in AI	US\$ Million	2012-2024
Out-of-Pocket Health	Percentage of Current Health	2012-2024
Government Effectiveness	Estimate	2012-2024
Individual Using the Internet	Percentage of Population	2012-2024

Source: World Development Indicators (WDI) & The OECD AI Policy Observatory.

In this paper, we show many problems in econometrics have been implemented by using the data, and Generalized Method of Moments (GMM) method is considered as an estimation method. In particular, old chestnuts such as endogeneity, measurement error, omitted variables bias, etc have come to life again. However, if these problems are not adjusted, inhomogeneous and biased estimates are obtained within the conventional fixed effects (FE) or random effects (RE) framework, which challenges the generalizability of the results. Purpose The GMM estimator boasts several important methodological constraints that make it suitable for the estimation of dynamic panel data models. First, it gets around endogeneity through instrumented co-regressors-value terms that are correlated with endogenous co-regressors (independent variables) but not correlated with endogeneity errors. This study draws on lagged values of the endogenous variables as the interior instruments that are an appropriate approach for achieving the parameters consistency (Arellano and Bond, 1991). This instrumental variable framework is also useful in alleviating bias caused by measurement error, another important issue with socio-economic and health-related panel datasets (Roodman 2009). Secondly, GMM suits dynamic panel data models mainly where the dependent variable has a dependence on its own past realizations. Unlike standard FE or RE estimators, which often overlook the dynamic relationship, GMM makes consistent estimates by using moment conditions that derive from the data (Arellano & Bover, 1995). Thirdly, GMM restricts consideration only to the aforementioned econometric problems, such as the autocorrelation and heteroskedasticity of the error structure. Such problems are also rather common in macroeconomic and health outcome datasets, and they would hamper the inference if uncontrolled. With GMM accommodating heteroscedasticity and autocorrelation, it gives better estimates when compared to the classical panel estimators (Blundell & Bond, 1998).

4. RESULTS AND DISCUSSION

Table 2 shows the descriptive statistics of the main variables used in this study and gives a fair idea about the nature of the data across countries and time. The main outcome variable, life expectancy at birth, has a mean of high eighty-five years and low dispersion. This assumes that data capture of situations where, by and large, populations live much longer, but the minimum figure does suggest some data captured settings where there are markedly lower life expectancies. The lagged value of life expectancy at birth also shows, in its high mean, a reflection of some persistence of health outcomes over time, while the larger variance in this lagged measure suggests that past health conditions varied a great deal in the sample. Such persistence is often referred to in health economics literature, and, indeed, improvement in life expectancy is gradual and cumulative (Bloom et al., 2018). GDP per capita has a high mean value but has a high standard deviation, implying differences in economic conditions within these countries. The high range of the minimum and maximum values is due to the presence of advanced and developing economies in the sample. California has been a case study in disparities because of existing economic gaps that result in differing levels of health in a population, due to their access to nutrition, health services, and education (Preston, 2007).

Investment levels in artificial intelligence can vary from medium to zero to record a medium level of investment, while other cases have recorded very high levels of investment. This distribution pattern indicates unequal subsistence of artificial intelligence technologies throughout the world with some of the economies leading in terms of technological adoption while some others still are lagging as virtual economic engines. Further, as AI slowly works its way into healthcare and administrative processes (these are the footprints that will determine who has them) these gaps can lead to an imbalance in

health improvements across countries (Topol, 2019). Studies show an average out of pocket health expenditure that is relatively high and to some degree fluctuates according to the population, a phenomenon indicative of variation in health care financing systems. While there are population subgroups that are relatively immune to direct health payment, while there are those with a much greater burden as far as both health care access and long-term opportunity are concerned (Xu et al. 2018). Concerning the government effectiveness, it is Narrowly Signaling, but walking right around a moderate average. Apart from the lower end of the range, most countries hover in the middle of those different rates. Good governance is an important determinant for implementation of health policies, distribution of resources and equity of access and therefore heterogeneity of this variable is important for labeling health disparities (Kaufmann et al. 2011). Finally, if one looks at the measure of the world's population with the internet as a proportion of their total population, one finds an average and broad stroke range not far away from forty percent of the population, but the variations range widely enough to include the high and low coefficients of penetration. Since digital technologies play an increasingly central role alongside health conditions, telemedicine, and efficient access to health information and services, the existing gap in internet usage is crucial for health outcomes such as life expectancy (Benda et al., 2020).

Table 2: Descriptive Statistics

Variables	Mean	Std. Dev.	Min	Max
LEB	95.194	1.2105	11.935	69.517
LEB (t -1)	90.902	3.1687	68.085	52.912
GDPK	13339.44	78322.7	33357.05	110425.89
INAI	30173.69	57489.68	0	372290
OPHE	98.96	7.238	3.2239	96.698
GOE	4.5771	0.8052	0.3665	3.1832
IUI	38.959	8.8091	85.903	74380.27

Table 3: Correlation Matrix

Variables	LEB	LEB (-1)	GDPK	INAI	OPHE	GOE	IUI
LEB	1.000						
LEB(-1)	0.105	1.000					
GDPK	0.4802	0.5909	1.000				
INAI	1.4854	-1.8235	0.8056	1.000			
OPHE	0.8717	0.387	-2.0976	-0.605	1.000		
GOE	0.6072	0.1305	0.6187	1.4813	2.5643	1.000	
IUI	0.1886	0.4214	0.0649	0.6177	1.4552	0.7725	1.000

The correlation matrix shows that the strength and direction of the correlations of the variables taken from the study can be seen in Table 3. The latter, in turn, provides some explanation as to the puzzle of the correlation of life expectancy at birth and its lagged value (recall that it is quite a weak positive correlation, frustratingly ad Kühn et al), which itself causes a proxy for health outcomes over a lifetime, the well-known issue of tracking. This increase in longevity is in line with a large body of literature of the demographic profession that suggests gains in life expectancy are incremental, building on past improvements in medical and social conditions (Bloom and Canning 2007). Additionally, life expectancy at birth is moderately positively and strongly correlated with gross domestic product per capita, which confirms that life expectancy follows familiar features of so-called 'Preston curves' - that is, that with increasing income, life expectancy improves (Preston, 2007). This implies that economic prosperity continues to be a powerful determinant of population health because developed societies would have been able to continue spending on health care, sanitation, nutrition, and education. There is a very high correlation between life expectancy at birth and investments in AI. In other words, if artificial intelligence (AI) increases in other areas, and specifically in medicine, then diagnoses, distribution of resources, and prevention of health-related problems could increase. The positive correlation also supports claims that artificial intelligence applications might revolutionize the management of health care and increase healthy life years (Topol, 2019). Note: The coefficient of correlation has to be taken with something of a pinch of salt since high correlations can sometimes be a spurious result of an anomaly in the form of the data or a measurement technique. The positive correlation between life expectancy and per capita out-of-pocket cash expense on health implies that health spending, in whatever way, comes from direct individual spending, contributes to an improvement in health outcomes. Whilst this scenario is useful as it assumes it to be additional to government spending on health, it of course raises important issues of financial protection and equity. Moreover, while direct payments may improve access to health services, in particular when used in pro-poor ways, their overuse can lead to a devastating financial impact on families of the poor (Xu et al., 2018). As a matter of fact, government effectiveness is

behind life expectancy at birth, thus confirming that efficient governance is vital for quality service delivery regarding health, equal opportunity for access, and implementation of effective health policies. However, according to available literature, good governance is consistently found to be associated with better health indicators because it alleviates inefficiencies while enhancing institutional capacity (Kaufmann et al., 2011). Last, the proportion of Internet users presents a positive correlation with life expectancy, but a weaker one. This indicates that while digital connectivity contributes to health outcomes, the correlation may be mediated by several other factors, such as digital literacy, infrastructure, and integration of online platforms in health systems. Nevertheless, the importance of digital access as a growing determinant of health equity has been recognized, especially regarding its role in providing access to health information and digital health services (Benda et al., 2020).

The tests of endogeneity in the model are fully seen in the outcomes of the Durbin-Wu-Hausman tests, as shown in Table 4, which provide evidence to show whether the explanatory variables in the model are possibly correlated with the error term, violating the precondition of exogeneity in all standard regression approaches. For a lagged dependent variable, both Durbin's and Wu-Hausman's tests probed zero probabilities, resulting in quite high statistical evidence for endogeneity. In keeping with theoretical expectations, the inclusion of a lagged dependent variable almost always leads to correlation with the error term due to dynamic persistence in the data (Nickell, 1981). This justifies why the life expectancy lagged value is treated as endogenous for proper instrumentation, considering subsequent estimations. Durbin-Wu-Hausman's test results for endogeneity, analyzed in Table 4, would indicate the presence of correlation between the explanatory variables in the model with the error term, violating the assumption of exogeneity. For the lagged dependent variable, both the Durbin test and the Wu-Hausman test return probabilities equal to zero, indicating strong statistical evidence of endogeneity. This finding is consistent with theoretical expectations, as the inclusion of a lagged dependent variable usually results in correlation with the error term because of the dynamic persistence in the data (Nickell, 1981). Therefore, further analysis must treat the lagged value of life expectancy as endogenous and instrument it properly. The other explanatory variables examined include gross domestic product per capita, investment in artificial intelligence, out-of-pocket health expenditure, government effectiveness, and internet usage, which themselves show comparatively higher values across both tests. These results lend themselves to the conclusion that these specific variables do not provide any significant evidence of endogeneity and can thus be reasonably regarded as exogenous in the model setting. This finding is consistent with the overall literature, which, for the case of macroeconomic and institutional variables when measured at the national level, usually satisfies exogeneity conditions provided careful accounting of omitted variable biases (Wooldridge, 2010). Absence of endogeneity for gross domestic product per capita is striking, as it means the relationship between income and life expectancy would be least likely determined within the dataset by reverse causality. This supports the strong general proposition whereby economic resources could make population health better, in accordance with the Preston curve framework (Preston, 2007). Results have also shown for investment in artificial intelligence that, although artificial intelligence influences health outcomes, probability tests do not indicate a strong inverse relation of health outcomes with investment levels in this sample. Indeed, test results indicate that out-of-pocket health expenses as well as government effectiveness do not incur significant endogeneity problems. This stands to reason, as financial pressure imposed by health expenses and quality of governance have generally been understood to be largely external influences on health outcomes, consistent with prior evidence where they have been linked to systemic structures and not to short-term feedback effects (Xu et al., 2018; Kaufmann et al., 2011). Finally, the proportion of people using the internet is also shown as exogenous; thus, although digital connectivity does influence consumption of health services indirectly through easier access to information and services, it is not much of an issue in this data context that effects flow from health status to internet uptake (Benda et al., 2020).

Table 4: Durbin Wu-Hausman Test For Endogeneity

Variables	Durbin test (Probability)	Wu-Hausman test (Probability)
lag dependent variable	0.0000	0.0000
GDPK	0.3777	0.5459
INAI	0.3262	0.3822
OPHE	0.1803	0.7877
GII	0.3586	0.5583
NAI	0.2138	0.8657

The generalized method of moments estimation results presented in Table 5 provide evidence on the determinants of life expectancy at birth, incorporating the dynamic structure of health outcomes. The improving trend was ascertained in terms of a positive lagged dependent variable, which is significant. This means that improvements in population health are cumulative; conditions of health at present seem to be strongly affected by achievements of the past, which supports demographic transition and health dynamics theory and evidence (Bloom & Canning, 2007). The values of the life

expectancy correlate with a positive and statistically insignificant relation to the per capita GDP. And with that, it means that in the context of the example (controlling for other determinants, of course) that income is not a determinant of longevity in any strong sense. Given that economic development is acknowledged as a fundamental determinant for better health (Preston, 2007), such a finding suggests that such a contribution margin might become diluted after the marginal threshold is further refined when other institutional and technological determinants are considered. Out-of-pocket health spending is positively but, in the case of some parasite infections, not significantly correlated with life expectancy, which indicates that private health spending is not equivalent to improved health within countries. That finding echoes the concern in the literature that high reliance on out-of-pocket payments can be a source of increasing inequality, benefiting those who are further down the socio-economic ladder and, as such, not always conducive to improving health (Xu et al., 2018).

Life expectancy is shown to be statistically significantly diminished with research into AI being increased. This counter-intuitive result may be framed less in terms of the ecological niche for diffusion frameworks of AI, but in terms of the possibility that a majority of resources intended for technology progression could initially be assigned to trial programs or high-end projects with much diffused health outputs. Or, by another logic, it could be the lack of focus on structural gaps, with countries investing in AI still suffering from inequalities in the health system or the population demographics that can counterbalance the advantage of AI (Topol 2019). Having a significant positive correlation with governmental effectiveness, life expectancy also shows the importance of strong institutions in the quality of health care and the neutrality of inclusion in the services offered by health care, as well as in health policy. The correlation that is observed fits very well with evidence that, in general, good governance is associated with better health outcomes by reducing inefficiencies and boosting the capacity of health systems (Kaufmann et al. 2011). The online platform makes it possible to deliver health education through the Internet, provide telemedicine, and facilitate greater communication between providers and patients. Sandor et al. have already highlighted that there is growing evidence that digital connectivity is one of the modifiable determinants of health equity within modern societies (Benda et al., 2020). Taken together, the results are consistent with the hypothesis that, all by themselves, economic resources do not contribute anything to life expectancy growth, but instead, institutional quality, digital access, and accumulation effects of past health outcomes do play a big role. While there's a potentially unintentional negative impact of AI investments, it also means that not only can technical breakthroughs be safeguarded in an IP regime, leading drivers of effective deployment can efficiently shift towards the health of all citizens.

Table 5: GMM Results
Dependent Variable: Life Expectancy at Birth

Variables	Coefficient	S.E	t-value	p-value
LEB (-1)	0.7606	0.0919	2.5349	0.000
GDPK	0.7224	0.7456	2.9321	0.8902
OPHE	0.1964	0.7586	8.5166	0.4715
INAI	-2.9968	0.1835	-9.9029	0.000
GII	0.8319	0.4278	9.8106	0.000
NAI	0.421	0.4492	2.3546	0.000
Constant	70.533	7.9316	3.4758	0.3769

5. CONCLUSION

This study has sought to extend the Grossman health capital model, introducing the idea of artificial intelligence as an independent component of the life expectancy determinant, across the complement of Organization for Economic Cooperation and Development (OECD) countries. The study also approached health in innovative ways in this age of advanced digitization and internet penetration on e-government and governance-health, in contrast to the conventional approach that is simply about economic resources and health spending had to determine health outcomes. In effect, an application of the Generalized Method of Moments (GMM) has succeeded in providing accounts for endogeneity-taking, measurement error, and dynamic persistence, and thereby removes this limitation of existing supplements. From the result, it can be seen that there is a positive and non-significant contribution of GDP per capita and out-of-pocket expenditure left on life expectancy. But when it comes to investment in so-called intellectual capital, this effect is rather complex. An investment in AI, on the other hand, can help capture short-term transitional expenditures, whose effects on health outcomes are obvious. Yet the adaptation of the artificial intelligence a technology except the strict govern and the widely use of the internet are defers remain as an important consideration for the improvement on the life expectancy. Precisely, complementing institutional and digital infrastructure is needed in order to open up health benefits from technical innovation. It also affirms the weak correlation between improvements in life expectancy and overall national economic prosperity and people's spending on goods linked to health and emerging as symbols of the ability of societies to integrate digital technologies into health systems that are well-regulated. This joins the growing literature on outlining sustainable investment in digital capacity to improve institutional quality outcomes to improve health for populations. There are all so

many policy implications as well: First of all, the framing ways should be pointed out to what the government can do to elucidate more than the contribution that money would make to the health care realm, as well as giving outspoken to the visible and invisible changes with a new wave health care online ideas and payments. That might be more internet links and information security systems and in cyber-topes. For this reason, it is important to ensure that effective governance frameworks are established to govern the use of AI and ensure that privacy and ethical considerations are taken into account. Such coverage is also key to ensuring that populations are similarly able to benefit from the ubiquitous use of AI in health. In short, artificial intelligence is an enabler and a challenge to public health in the future. While the initial cost of adoption can be high, the longer-term benefits in the way that the technology synergizes with good governance and digital accessibility would be huge. And in that context, AI in the broader health capital stock means that these leased bigger systems are able to assist countries of Organization for Economic Cooperation and Development in terms of greater health sustainable populations in the quest of countries' growth, include, even sustainable development.

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