Healthcare system efficiency:
Beyond healthcare expenditures

PhD. Dissertation

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I would like to dedicate this thesis to my two little nephews –

Maryna and Ilya Greyda.

«If you would learn properly day and night,

Then wisdom would be yours

…

You should learn and read,

And learn from others,

And don't shy away from yours.

Because those who forget their Motherland

God punishes them.

Children shun those,

And don't let them into the house.

Taras Shevchenko - My friendly message to my dead, living and unborn compatriots, in Ukraine and not in Ukraine

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ABSTRACT

This PhD thesis aims to contribute to the sustainability and resilience of modern healthcare systems by investigating the concept of healthcare efficiency and its determinants at both macro and micro levels. The study objectives were revised in light of the challenges faced by healthcare systems, including demographic change, the rise of chronic diseases, and financial pressures. The thesis focused on three research subjects: the relationship between life expectancy at birth and healthcare expenditure, healthcare expenditure disparities among high-income countries, and the efficiency of healthcare as a strategic management approach.

The first research subject analyzed the factors influencing life expectancy at birth through a cross-country study involving 138 countries from 2000 to 2018. The study examined the relationship between healthcare expenditure, socioeconomic factors, and institutional quality.

The second research subject delved into the relationship between healthcare efficiency and healthcare expenditure for high-income countries. More specifically, to assess the role of healthcare expenditure and other factors in driving the observed outcomes. The study analyzed data from 37 countries between 2000 and 2019 to determine if variations in health outcomes were solely attributable to differences in healthcare expenditure or if other factors also played a role.

The third research subject comprehensively understood healthcare efficiency as a strategic concept. The study introduced a conceptual framework for implementing healthcare efficiency, with a focus on the role of management in implementing efficiency measures. This framework was then applied to a case study of a medium-sized hospital in Spain, specifically in its surgical area.

To summarise this thesis' main findings, I find that effective management arises as a crucial factor in driving healthcare system efficiency. The thesis also proposed adopting a standardised methodology as a strategic approach to managing efficiency. Additionally, the study identified the volume of healthcare expenditure as a significant factor affecting healthcare outcomes. However, the results also underscored the

importance of considering socioeconomic factors and institutional quality. Furthermore, the findings highlighted the influence of an ageing population, income inequality, lifestyle factors, research and development expenditure, and pharmaceutical spending on health outcomes.

Overall, the thesis provides insights and recommendations for policymakers and healthcare managers to effectively improve healthcare outcomes and allocate resources while considering socioeconomic factors and local contexts.

RESUMEN

Esta tesis de doctorado tiene como objetivo contribuir a la sostenibilidad y resiliencia de los sistemas de salud modernos mediante la investigación del concepto de eficiencia en la atención médica y sus determinantes tanto a nivel macro como micro. Los objetivos del estudio fueron revisados a la luz de los desafíos que enfrentan los sistemas de salud, como el cambio demográfico, el aumento de las enfermedades crónicas y las presiones financieras. La tesis se centró en tres temas de investigación: la relación entre la esperanza de vida al nacer y el gasto en salud, las disparidades en el gasto en salud entre países de altos ingresos y la eficiencia de la atención médica como enfoque de gestión estratégica.

El primer tema de investigación analizó los factores que influyen en la esperanza de vida al nacer a través de un estudio transversal en 138 países desde 2000 hasta 2018. El estudio examinó la relación entre el gasto en salud, los factores socioeconómicos y la calidad institucional.

El segundo tema de investigación profundizó en las disparidades en el gasto en salud entre países de altos ingresos. El estudio analizó datos de 37 países entre 2000 y 2019 para determinar si las variaciones en los resultados de salud se debían únicamente a diferencias en el gasto en salud o si otros factores también desempeñaban un papel.

El tercer tema de investigación presentó una comprensión integral de la eficiencia en la atención médica como concepto estratégico. El estudio introdujo un marco conceptual para implementar la eficiencia en la atención médica, con énfasis en el papel de la gestión en la implementación de medidas de eficiencia. Este marco se aplicó a un estudio de caso de un hospital de tamaño mediano en España, específicamente en su área quirúrgica.

Entre los hallazgos del estudio, se destacó la importancia de una gestión efectiva en la implementación de la eficiencia en los sistemas de salud. La tesis también propuso la adopción de una metodología estandarizada como enfoque estratégico para gestionar la eficiencia. Además, el estudio identificó el volumen del gasto en salud como un factor significativo que afecta los resultados de salud. Sin embargo, los resultados también

subrayaron la importancia de considerar los factores socioeconómicos y la calidad institucional. Además, los hallazgos destacaron la influencia de una población envejecida, la desigualdad de ingresos, los factores del estilo de vida, el gasto en investigación y desarrollo y el gasto farmacéutico en los resultados de salud.

En general, la tesis proporciona ideas y recomendaciones para los responsables de la formulación de políticas y los gestores de la atención médica para mejorar los resultados de salud y asignar los recursos de manera efectiva, teniendo en cuenta los factores socioeconómicos y los contextos locales.

АНОТАЦІЯ

Ціль даної дисертаційної роботи полягає в сприянні сталості та стійкості сучасних систем охорони здоров'я шляхом дослідження концепції ефективності охорони здоров'я та її визначальних чинників на макро- та мікрорівнях. Цілі дослідження були поставлені з огляду на виклики з якими зіштовхуються системи охорони здоров'я, такі як демографічні зміни, зростання хронічних захворювань та фінансова нестійкість. Дана наукова робота сфокусована на трьох дослідницьких темах: взаємозв'язок між тривалістю життя при народженні та витратами на охорону здоров'я, різниця у витратах на охорону здоров'я серед країн з високим рівнем доходів та ефективності охорони здоров'я як стратегічного підходу до управління.

В першій дослідницькій темі біло проаналізовано фактори, що впливають на тривалість життя при народженні, за допомогою міжнародного дослідження, яке охопило 138 країн у період з 2000 по 2018 роки. Був проаналізований зв'язок між витратами на охорону здоров'я, соціоекономічними факторами та показником якості інституцій.

Друга дослідницька тема стосується різниці у витратах на охорону здоров'я серед країн з високим рівнем доходів. В цій частині були опрацьовані дані 37 країн у період з 2000 по 2019 роки, щоб визначити, чи пов'язана різноманітність результатів у сфері охорони здоров'я виключно з різницями у рівні витрат на охорону здоров'я, або ж на них впливають інші фактори.

Третя дослідницька тема пропонує всебічне розуміння ефективності охорони здоров'я як стратегічної концепції. Дослідження вводить концептуальну модель впровадження ефективності охорони здоров'я, з фокусом на роль менеджменту у впровадженні заходів щодо ефективності. Ця модель була застосована на практиці в лікарні середнього розміру в Іспанії, зокрема в її хірургічному підрозділі.

Серед результатів дослідження було відзначено важливість менеджменту в процесі впровадження ефективності серед систем охорони здоров'я, а також була запропонована методологія управління ефективністю з точки зору стратегічного

підходу. Крім того, дослідження виявило значущість обсягу витрат на охорону здоров'я як важливого фактору, що впливає на результати охорони здоров'я. Однак результати також підкреслили важливість врахування соціоекономічних факторів та показників якості інституцій. Також, дослідження виявили неабиякий вплив на результати охорони здоров'я таких фікторів як старіння населення, нерівності у доходах, факторів способу життя, витрат на дослідження та розвиток і фармацевтичних витрат.

У цілому, дисертація надає уявлення та рекомендації для політиків та керівників у сфері охорони здоров'я з метою покращення результатів у системах охорони здоров'я та ефективного розподілу ресурсів, з урахуванням соціоекономічних факторів та місцевого контексту.

CONTENTS

LIST OF ACRONYMS

AI	Artificial Intelligence
AGO	Angola
ALB	Albania
ARE	United Arab Emirates
ARG	Argentina
AUS	Australia
AUT	Austria
BDI	Burundi
BEL	Belgium
BEN	Benin
BFA	Burkina Faso
BGD	Bangladesh
BGR	Bulgaria
BHR	Bahrain
BIH	Bosnia and Herzegovina
BLR	Belarus
BLZ	Belize
BOL	Bolivia
BRA	Brazil
BRN	Brunei Darussalam
BTN	Bhutan
BWA	Botswana
CAN	Canada
CHE	Switzerland
CHL	Chile
CHN	China
CIV	Cote d'Ivoire
CMR	Cameroon
COD	Congo, Rep.

COL	Colombia
CPV	Cabo Verde
CRI	Costa Rica
CYP	Cyprus
CZE	Czech Republic
DEU	Germany
DJI	Djibouti
DNK	Denmark
DOM	Dominican Republic
DZA	Algeria
ECU	Ecuador
EGY	Egypt, Arab Rep.
EHR	electronic health records
ERI	Eritrea
ESP	Spain
EST	Estonia
ETH	Ethiopia
EU	European Union
FIN	Finland
FJI	Fiji
FRA	France
GAB	Gabon
GBD	Global Burden of Disease
GBR	United Kingdom
GDP	Gross Domestic Product
GEO	Georgia
GHA	Ghana
GIN	Guinea
GMB	Gambia, The
GNB	Guinea-Bissau
GNQ	Equatorial Guinea

GRC	Greece
GTM	Guatemala
GUY	Guyana
HCE	Health care expenditure
HCS	Health care system
HCSE	Health care system efficiency
HND	Honduras
HRV	Croatia
HTI	Haiti
HUN	Hungary
IDN	Indonesia
IND	India
IRL	Ireland
IRN	Iran, Islamic Rep.
IRQ	Iraq
ISL	Iceland
ISR	Israel
ITA	Italy
JAM	Jamaica
JOR	Jordan
JPN	Japan
KAZ	Kazakhstan
KEN	Kenya
KGZ	Kyrgyz Republic
KOR	Korea, Rep.
KWT	Kuwait
LAO	Lao PDR
LBN	Lebanon
LBY	Libya
LEB	Life expectancy at birth
LKA	Sri Lanka

LMICs	Low-income and middle-income countries
LSO	Lesotho
LTU	Lithuania
LUX	Luxembourg
LVA	Latvia
MAI	Mediterranean adequacy index
MAR	Morocco
MDA	Moldova
MDG	Madagascar
MEX	Mexico
MLI	Mali
MLT	Malta
MMR	Myanmar
MNG	Mongolia
MOZ	Mozambique
MRT	Mauritania
MUS	Mauritius
MYS	Malaysia
NAM	Namibia
NCDs	Non-communicable diseases
NGA	Nigeria
NGOs	Non-profit organization
NIC	Nicaragua
NLD	Netherlands
NOR	Norway
NPL	Nepal
NZL	New Zealand
OECD	The Organisation for Economic Co-operation and Development
OLS	ordinary least squares
OMN	Oman
PAK	Pakistan

PAN	Panama
PER	Peru
PgMP	Program Management Professionals
PHL	Philippines
PMI	Project Management Institute's
POL	Poland
PRT	Portugal
PRY	Paraguay
QAT	Qatar
R&D	Research and development
ROI	Return of Investment
ROU	Romania
RUS	Russian Federation
RWA	Rwanda
SAU	Saudi Arabia
SDN	Sudan
SEN	Senegal
SGP	Singapore
SHA 2011	A System of Health Accounts 2011
SLE	Sierra Leone
SLV	El Salvador
SRB	Serbia
svk	Slovak Republic
SVN	Slovenia
SWE	Sweden
TCD	Chad
TGO	Togo
THA	Thailand
TJK	Tajikistan
TKM	Turkmenistan
TUN	Tunisia

TUR	Turkey
TZA	Tanzania
UGA	Uganda
UKR	Ukraine
URY	Uruguay
USA	United States
UZB	Uzbekistan
VEN	Venezuela, RB
WDB	World Data Bank
WHO	World Health Organization
YEM	Yemen, Rep.
ZAF	South Africa
ZMB	Zambia

LIST OF ABBREVIATIONS

aaw	Non-health-specific average annual wages
ac	Alcohol consumption
ap	Antibiotic prescribing
ashce	Ancillary services
avwgi	Average WGI
cca	Coronary artery bypass graft surgery
cgd	Central government debt
comphce	Health care expenditure by Compulsory contribution schemes (HF1.2) of Total HCE
crpr	Credit to Private non-financial sector from All sectors at Market value
ct	Equipment: Computed tomography scanners units
dam	Acute myocardial infarction
didac	Data accessibility
didav	Data availability
dig	OURData Index global
digs	Government Support to re-use
dmb	Discharges: Mental behavioural
dp	Pneumonia
dpd	Chronic obstructive Pulmonary disease and bronchiectasis
ect	Computed tomography
ehci	eHealth composite indices between 2013 and 2018
emr	Examinations: Magnetic resonance imaging units
gahce	Governance and administration
gdp	Real GDP growth
gdpgr	Real GDP growth
ggd	General government debt
ghrd	Government budget allocations for R&D, R&D related to Medical and health sciences - financed from sources other than UF General Uiversity Funds

ghrdguf	Government budget allocations for R&D, R&D related to Medical and health sciences - financed from GUF General University Funds
gii	GLOBAL INNOVATION INDEX
gini	Gini Index
gmp	Practising workforce: Generalist medical practitioners
govhce	Health care expenditure by Government schemes (HF1.1) of Total HCE
gval	Value
gvol	Volume
hb	Hospital beds
hc	Human Capital Index
hcegdp	HCE % gdp
hceoopp	Out-of-pocket spending
hgerd	GERD - Medical and health sciences
hrd	Gross domestic R&D expenditure on health (health GERD)
ichce	Inpatient curative and rehabilitation care
inc_clas1	Countries aggrupation by income: Low income
inc_clas2	Countries aggrupation by income: Low middle income
inc_clas3	Countries aggrupation by income: Upper middle income
inc_clas4	Countries aggrupation by income: High income
index_hcr	Health care resources Index
index_hcru	Health care utilization Index
infl	Inflation
leb	Life expectancy at birth
lsm	Length of stay per capita: Acute myocardial infarction
lthb	Long-term care beds
lthce	Long-term care
mdiet	Mediterranean diet
mghce	Medical goods
mm	Mammography machine units
mr	Equipment: magnetic resonance imaging units
nun	No unmet needs to declare

ochce	Outpatient curative and rehabilitation care
op	Obese population
ophce	Health care expenditure by Out-of-pocket schemes (HF3) of Total HCE
pchce	Preventive care
phce	Primary Health Care
pn	Practising workforce: nurses
pop	Population
pop65	Population > 65 years
popden	Population density
popps	Private out-of-pocket spending
pp	Practising workforce: Practising physicians
ppris	Private Insurance Scheme
pps	Public spending
pshce	Pharmaceutical spending
rd	Research and development expenditure
rgp	Remuneration of general practitioners
rhn	Workforce remuneration: hospital nurses
rpopden	Rural population
rs	Remuneration of specialists
rt	Radiation therapy equipment units
scat	Surgical procedures: Cataract surgery
sce	Cesarean delivery
sh	Hysterectomy
shr	Total hip replacement
skr	Surgical procedures: Total knee replacement
smp	Practising workforce: Specialist medical practitioners
snomed	snomed
tc	Tobacco consumption
thcepc	Health care expenditure per capita
tmr	Defines jurisdiction, liability or reimbursement of eHealth services (e.g. telehealth)?

tms	Has national legislation, strategy or policy on the use of telemedicine in 2018?
unet	Too expensive or too far to travel or waiting list
unnt	No time
unte	Too expensive
unteft	Too far to travel
ur	Unemployment rate
volhce	Health care expenditure by Voluntary payment scheme (HF2) of Total HCE
wgicc	Control of Corruption
wgige	Government effectiveness
wgipsnv	Political Stability No Violence
wgirl	Rule of Law
wgirq	Regulatory Quality
wgiva	Voice and Accountability

LIST OF SYMBOLS

$\boldsymbol{\varepsilon_{it}}$	error term
$\propto_{\boldsymbol{i}}$	country-specific effect
$\boldsymbol{\delta_t}$	period-specific shifter
$\boldsymbol{u_{it}}$	a random, idiosyncratic error component
β_n	control variables
Y*	latent variable
$\boldsymbol{j}$	category probability

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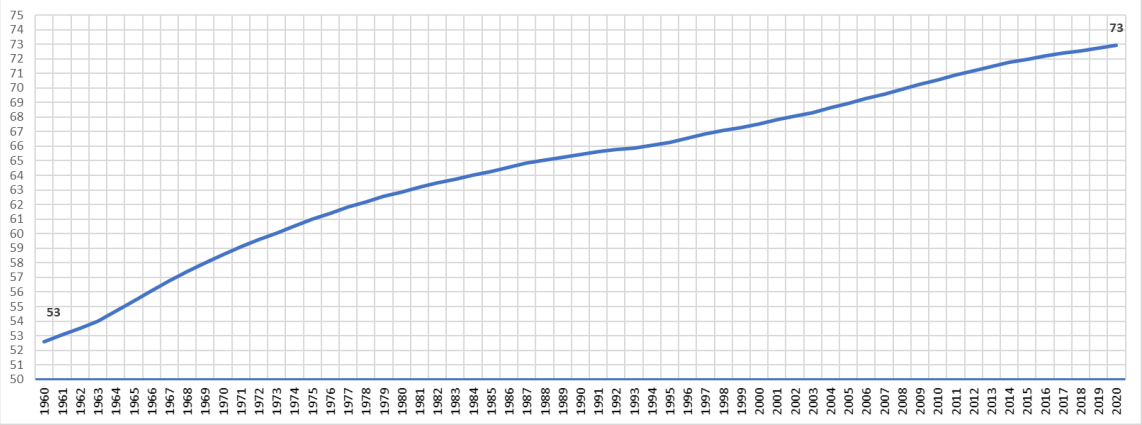
1. INTRODUCTION

"The definition of insanity is doing the same thing over and over again, but expecting different results."

Albert Einstein

Health care is one of the sectors that has never stopped developing and perfecting itself. Only during the last 150 years has a range of powerful advances been made. Among others, we can highlight the improvement in the quality of health documentation, the incorporation of sanitary commissions, constant innovative and technological developments, advances in medical education, pharmaceutical discoveries, the creation of health care systems and the adoption of new productive management methods [1]. As a result, the worldwide Life expectancy at birth has grown on average by around 20 years since global data started to be available (1960) (Figure 1. 1).

Figure 1. 1 Evolution of Life expectancy at birth (1960-2018) at the world level, years



Source: Elaborated by the author, data used from WDB

Before 2019, the world's health care was mainly driven by the 2030 Sustainable Development Goal number 3, adopted by the United Nations General Assembly in September 2015, to ensure healthy lives and promote well-being for all ages [2]. This broad health goal calls for universal health coverage, defined as access for all people and communities to services they need without financial hardship.

However, the true importance of health care was especially recognized due to the COVID-19 pandemic. Dramatic loss of human lives[1] worldwide presented unprecedented challenges to public health care systems. Thus, additional programs for health care improvement were set up. For instance, EU4Health 2021-2027, established by Regulation (EU) 2021/522 [3], provides funding to eligible entities, health organizations and NGOs from European Union (EU) countries or non-EU countries associated with the programme. There are four objectives: improve and foster health in the Union, protect people in the Union from severe cross-border threats to health, improve medicinal products, medical devices and crisis-relevant products, and strengthen health systems.

Both previous achievements and future healthcare goals are mainly possible due to stable economic support. Global spending on health was US$ 8.3 trillion in 2018, or 10% of global GDP [4]. However, to date, it has been proven that additional health spending is needed to progress to achieve the goals mentioned in the Sustainable Development Goal 3 targets. It may variate between $274 billion per year by 2030 and US$371 billion or an additional $41 (range 15–102) or $58 (22–167) per person, respectively, by the final years of scale-up [5].

In concurrence with the probable threat of financial shortage during the following years, we cannot ignore the challenges facing medicine—population growth and the burden of chronic diseases. The combination of increasing demand and funding scarcity calls for innovative approaches to the healthcare systems functioning based on the principles of efficiency, sustainability and value.

In the next section, we will try to understand the context of the modern health care system by analysing its historical background, classification types and theoretical model approaches.

[1] https://covid19.who.int/

1.1. Heath care system

1.1.1. History and classification

The modern approach to Health systems appeared after 1950, as Europe was healing from the 2nd World War. With a political shift to the left, governments responded to public demands for affordable health services accessible to all. Until the 1970s, health systems shared one concern: funnelling an average of 7% of national Gross Domestic Product (GDP) collected through taxes and labour contributions into healthcare services [6].

Since then, the most common classification approach has defined four types of healthcare systems, as these models influence most countries. There are four basic models, the Bismarck model, the Beveridge model, the National Health Insurance (single-player system) model, and the out-of-pocket model [7] [8]**.**

The Bismarck Model

The Bismarck Model, also known as the German model, is widely recognized as one of today's most significant healthcare models. Germany's longstanding universal healthcare system has served as a benchmark for numerous countries, including France, Belgium, Switzerland, the Netherlands, and others when developing their healthcare systems.

Before establishing universal healthcare, Germany had sickness funds in place. These funds allowed members to contribute regular payments, which would assist them during times of illness. Following the unification of Germany in 1871, Chancellor Otto von Bismarck implemented the German healthcare system through the Health Insurance Act in 1883. Emperor Wilhelm recommended this system in his Imperial Message in 1881 ("Kaiserliche Botschaft"), urging the Reichstag to consider welfare development to address the social challenges of industrialization.

During that time, Bismarck faced significant political pressure to quell social unrest while maintaining German economic growth and efficiency (Social Security Administration). The laws introduced under the Health Insurance Act mandated that all workers earning

less than 2,000 RM (Reichsmark) become members of the public health system. Bismarck designed a wage-based system, with workers paying two-thirds of the contributions and employers contributing the remaining one-third. The coverage included a maximum of 13 weeks of illness, provision of medicine during that period, the freedom to choose a doctor, and 50% wage replacement in the event of work incapacity.

The Bismarck Model served as the foundation for the first healthcare system. As previously mentioned, other countries began adopting the "Bismarck Model" and establishing their universal healthcare systems. These systems share common characteristics, such as hospitals, doctors, and insurance providers ("sickness funds") being private entities rather than state-owned. Although independent of the state, the government heavily influences the system. Insurance companies are required to accept all applicants, and individuals are mandated to have insurance coverage. The healthcare system is financed by contributions from insured employees and their employers, while the insurance companies operate on a non-profit basis.

The Beveridge Model

The Beveridge Model of healthcare systems development began when British economist and social reformer Beveridge was approached for advice on rebuilding Great Britain after World War II. In his renowned "Beveridge Report" in 1942, he presented a model for a welfare state to the government, which was implemented gradually under Prime Minister Clement Attlee from 1945 onwards. The National Health Act of 1948 established the first National Health Service, providing free medical services to the entire population.

The key features of this model include government financing of health insurance through taxes, granting the government significant control over the healthcare system. Additionally, many hospitals are state-owned, many doctors are government employees, and others are paid through taxes. The "Beveridge Model" has also served as a clear example for other countries such as Cuba, New Zealand, and Spain.

The National Health Insurance Model

Another unique healthcare system in this context is the "National Health Insurance Model," which combines the Bismarck and Beveridge models. In this model, hospitals, doctors, and insurance providers are typically private entities but receive financing through government insurance programs. Citizens contribute to these programs through either taxes or premiums. Derivatives of this model can be observed in countries like Canada, Taiwan, and South Korea.

The Out-of-Pocket-Model

The out-of-pocket model is, in fact, the most prevalent healthcare model worldwide. It is primarily found in countries that lack the resources or organization to establish a comprehensive healthcare system, particularly in rural regions of Africa, India, China, and similar areas. Under this model, individuals are responsible for paying their medical expenses out of their pockets if they have access to healthcare services. Unfortunately, they are often denied medical treatment if they cannot afford the costs.

However, nowadays, the existence of one outclassing system cannot be observed. Some authors [9] [10] call to use such terms as Public Assistance health care system, Health Insurance, National Health Service and Intermediate Forms. While others propose more sophisticated approaches, for example, as follows: Voluntary insurance, Social health insurance, Residual programs, Compulsory national health insurance, and Universalist systems [11]. Alternatively, the categorization is based on supply, public-private mix, access regulation, primary care orientation and performance [12]. In this case, the types of health care system are:

- Type 1: The supply- and choice-oriented public systems
- Type 2: The performance- and primary-care-oriented public systems
- Type 3: The regulation-oriented public systems
- Type 4: The low-supply and low-performance mixed systems
- Type 5: The supply- and performance-oriented private systems

After studying different views of the classification of health care systems, we can conclude that the common denominator in all classification approaches is the financial source and volume of health care systems. Thus, hereafter we will use A System of

Health Accounts 2011 [13] to analyse the prevalence of healthcare systems' financial schemes.

For instance, according to SHA 2011, healthcare expenditures are divided into the following main groups:

- HF.1.1 Government schemes
- HF.1.2 Compulsory contributory health insurance schemes
- HF.2 Voluntary health care payment schemes
- HF.3 Household out-of-pocket payment
- HF.4 Rest of the world financing schemes (non-resident)

As Figure 1. 2 Distribution of the global Healthcare expenditure by the financial scheme, as % of current health expenditure, 2000-2020shows, the Governments cover around 40% of the global healthcare expenditure, compulsory contributions barely reach 16%, while Voluntary and Out-of-pocket payments overpass the percentage of 43%.

The following section provides a state-of-the-art study of the theoretical models of healthcare systems.

1.1.1. Theoretical model of present health care systems

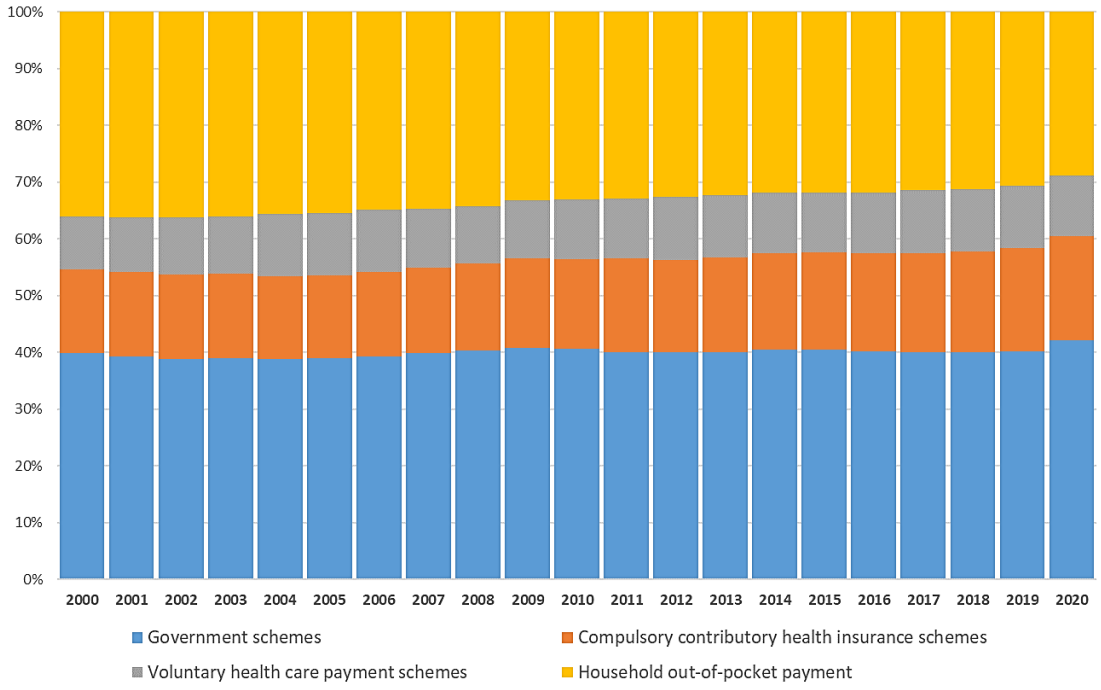
In order to understand the structure of a modern healthcare system, we analyze existing theoretical models.

The most completed officially represented theoretical model of the healthcare system is the framework visualized by World Health Organization in 2009 [14]. It consisted of two main parts: system building blocks as input and overall goals or outcomes. Those are related to access quality and quality safety values. Input, in this case, includes service delivery, health workforce, information, medical products, vaccines and technologies, financing and leadership or governance. Output is improved health, responsiveness, social and financial risk protection, and efficiency.

Later the structure of healthcare was linked to health accounts. According to this framework, health care is a consumption, financing and provision system. Health system

functions and output as instrumental objectives represent the input. The overall objectives are health, equity in health, financial risk protection and responsiveness.

Figure 1. 2 Distribution of the global Healthcare expenditure by the financial scheme, as % of current health expenditure, 2000-2020



Source: Elaborated by the author, data used from WHO

However, some authors [15] prefer to put a patient at the centre of the theoretical framework of the health care system. It consists of input and output with a patient or health care provider in the centre. It also included external influences and other links with the health system.

Another group of authors [16] represented health care as a four-level system. In the centre is a patient mostly connected with health care providers. The care team collaborates closely with the organizational level providing infrastructure and resources. As the last layer is drowned, the environment represents regulatory, market and policy influence.

The Encyclopedia of Health Economics [17] neither has a clear nor a unique definition of the health care system. It is defined as a production process mainly consisting of the doctors and nurses, premises and equipment as input. Then the production process is where the population's health is an outcome.

There is another approach to the healthcare system [18]. It divides the system into three layers: meso, micro and macro. The Meso level is the organizational and local level. The micro level is the individual level. At these two levels are linked citizens and patients with providers and health managers, which at the same time are connected with policy elites. The macro level includes the global and national context of health care.

After a detailed study of health care system theoretical frameworks, we can conclude that there does not exist a clear and unique definition of the health care system.

In the next section, we analyse the shortcomings of the present healthcare systems.

1.2. Motivation and rationale

"The promotion of health and the prevention of disease, disability and injury are a priority and necessary to the sustainability of the health system [19]."

Despite significant advances in healthcare, there are multiple factors that push systems to find new responses. At the same time, others pull healthcare to potential improvements.

Among emerging factors, we may list demographic changes, the burden of diseases, and the overall ecological situation. For instance, according to World Health Organization (WHO) [20], the global population is experiencing increased life expectancy. This trend is observed in every country as the size and proportion of older individuals in the population continue to grow. By 2050, the global population of people aged 60 and older is projected to double, reaching 2.1 billion. The number of individuals aged 80 years or older is also expected to triple between 2020 and 2050, reaching 426 million.

Based on the results of the last estimations of the Global Burden of Disease (GBD) [21], nowadays, 64% of the total burden is Non-communicable diseases (NCDs), with cardiovascular, cancer and musculoskeletal diseases on top of the list. Considering other scientific works [22], this trend will continue due to the high level of physical inactivity

of the population. More than 500 million new cases of preventable major NCDs will occur globally by 2030 if the prevalence of physical inactivity does not change, with direct health-care costs of $520 billion.

The role of healthcare in ecological crises is ambiguous. On the one hand, it is a victim of the consequences. In 2016, as much as 24% of all deaths worldwide were attributable to the environment [23]. On the other hand, healthcare causes global environmental impacts that range between 1% and 5% of total global impacts [24].

Regrading pull factors, we may distinguish some areas of healthcare that have potential improvement.

For instance, recent studies [25] estimated that poor-quality health systems still result in more than 8 million deaths per year only in low-income and middle-income countries, leading to economic welfare losses of $6 trillion. Moreover, across OECD countries, a significant share of health care system spending and activities are wasteful and harm our health at worst. One in ten patients in OECD countries is unnecessarily harmed at the point of care. More than 10% of hospital expenditure is spent on correcting preventable medical mistakes or infections that people catch in hospitals.

Pharmaceuticals are also a subject to discuss. The market penetration of generic pharmaceuticals – drugs with effects equivalent to branded products but typically sold at lower prices – ranges between 10-80% across OECD countries. Moreover, a third of OECD citizens consider the health sector to be corrupt or even highly corrupt [26].

At a time when public budgets are under pressure worldwide, it is alarming that around one-fifth of health expenditure makes no or minimal contribution to good health outcomes. In other words, governments could spend significantly less on health care and improve patients' health [27].

Further, we reveal in detail some of the pull factors.

1.2.1. Quality of health care service

1.2.1.1. Cost of poor-quality health care

The costs of poor-quality health care still lead to 98 000 and 400 000 fatalities annually in the United States. This number is presumably much higher globally [28].

By 2050 the share of the population aged 80 and over will more than double. Ironically, gains in longevity are styling chronic diseases and mental ill health effects, which will increase demand for health services, particularly long-term care [29].

Smoking, drinking and obesity continue to cause premature deaths and worsen the quality of life. Barriers to access persist particularly amongst the less well-off, where limitations in health literacy also imperfect communication strategies.

Recent studies [24] discovered that health providers in low-income and middle-income countries (LMICs) often do less than half of recommended evidence-based care actions. For example, only two in five women delivered in a facility were examined within one hour after birth. Approximately one-third of patients experience disrespectful care, short consultations, poor communication, or long wait times. Inadequate integration across platforms and weak referral systems undermine the ability of health systems to care for complex and emerging conditions.

Less than one-quarter of people in LMICs believe that their health system works well, compared with half of people in high-income countries. Clinics and providers with good performance can be found in every country, and studying them can inform the country-of broad efforts for improvement.

High-quality health care is inequitably distributed in many countries, with poor and vulnerable groups having worse quality care in terms of competent care and user experience. People can be especially vulnerable to poor-quality care based on particular care settings, health conditions, and demographic factors.

1.2.1.2. Medical errors

The Quality Interagency Coordination Task Force, a Federal Agency for Healthcare Research and Quality, describes a medical error as a “failure of a planned action to be

completed as intended or the use of a wrong plan to achieve an aim. Errors can include problems in practice, products, procedures, and systems". Thus, a medical error is usually a preventable adverse effect of medical care [30].

Moreover, according to the studies [25], 44% of serious medical errors are preventable. The most common medical errors are related to using healthcare products, especially medication [29]. However, a recent investigation [26] [27] named other problems when providing health care. We resumed them by category in Table 1. 1

Table 1. 1 Categories of medical errors

Category	Definition
Surgical Errors	Over 200 million surgical procedures are performed each year globally, and despite awareness of adverse effects, surgical errors continue to occur at a high rate. Surgical errors account for a significant number of adverse events. Operating on an incorrect body part is a common source of surgical error. Also, robotic surgery increases accidental haemorrhages caused by lacerations and injury to surrounding tissues.
Diagnostic errors	According to the Joint Commission, diagnostic errors result in death or injury to 40,000 to 80,000 patients per year [32]. Diagnostic errors are most common in primary care solo practice due to workload and the inability to cross-reference easily with colleagues [28].
Tubing Misconnection	Errors involving tube and catheter connections are standard. These adverse events can have life-threatening effects if a misconnection is not caught early and corrected [34].
Device and Equipment errors	There are four common pitfalls: inadequate maintenance, inadequate plan for implementing technology into practice, poor technology design that does not consider human factors and ergonomic principles and poor technology interface with the environment and patient.
Iatrogenic Infection	A healthcare-related infection increases complications, length, and cost of the hospital stay. They add close to $35 billion to the annual cost of healthcare in the United States [35]. Causes include failure to practice basic hand hygiene and poor technique in placing indwelling and foley and vascular catheters.
Falls	Each year, over one-third of people over 65 suffer a fall, and one-third of these falls cause injuries [17] [36]. Extrinsic factors include environmental hazards and medications. These may be modifiable and preventable.

Information Technology	Perhaps the most common IT error is accidentally charting information or placing orders on the wrong patient [37].
Ineffective verbal communication	Risk factors include: disruptive behaviour, including rude language or verbal abuse, environmental noise issues such as cell phones; cultural differences among patients and providers; hierarchy issues; providers acting as autonomous agents; personality differences; language barriers; lack of working as a team, multiple conversations are co-occurring, socio-economic variables, such as education and literacy [38].
Written Errors	Using non-standard abbreviations and illegible handwriting, failure to question inappropriately written orders, and failure to complete correct specimen labelling are familiar sources of written communication errors.
Patient Hand-offs	This can occur if incorrect information is passed to the receiving clinician and there is a failure to remember to follow-up on all of the pending issues [39].
Acute Intervention	A code or arrest, intubation, or other acute, life-threatening event is a high-risk situation for medical error. Due to the rapidity of decision-making and the instant need for life-saving drugs and procedures, there is a significant risk of error.

Higher error rates usually occur in stressful, fast-paced environments such as emergency departments, intensive care units, and operating rooms. Medical errors are associated with extreme age, high acuity, and new procedures. Errors often occur when necessary personnel are not available when needed. When multiple practitioners are involved, an incomplete preoperative assessment may occur. Students, interns, residents, and fellows may be inadequately supervised due to time constraints or a lack of understanding of their abilities. Inconsistent postoperative monitoring procedures may lead to errors.

Further, the role of primary care in the health care system is described.

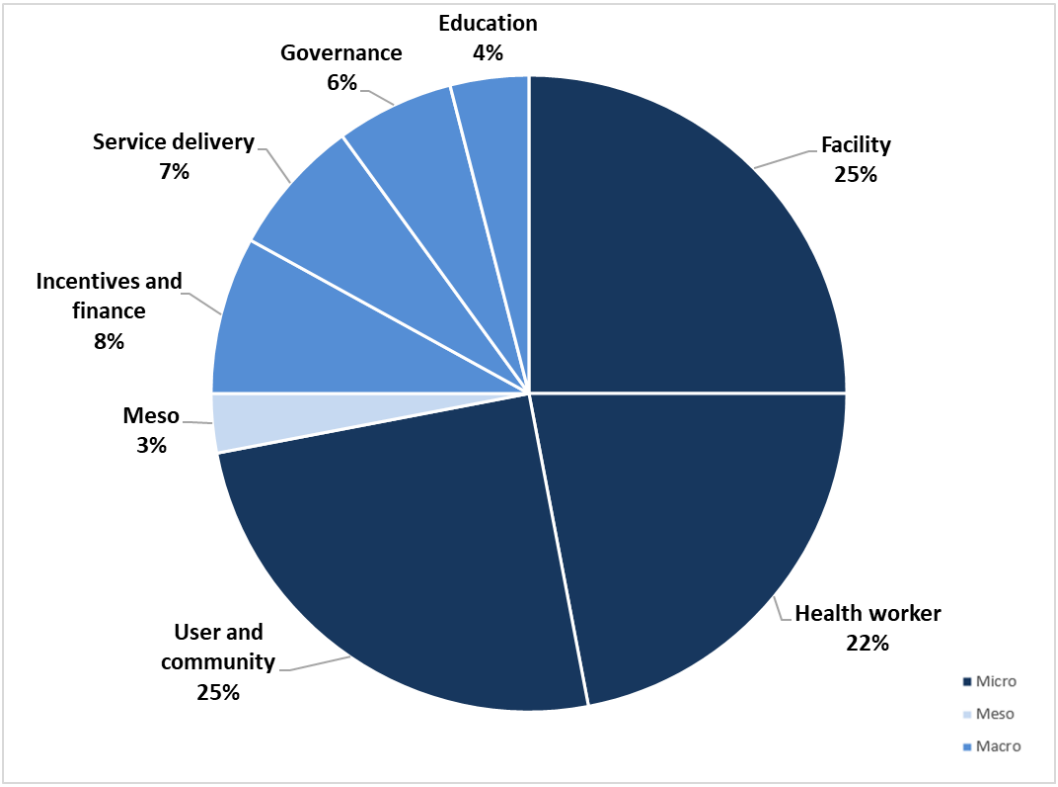
1.2.1.3. Weak primary care

As we saw before, primary care is the most sensitive area to making medical errors due to workload and the inability to cross-reference easily with colleagues [28]. Indeed, some studies suggest that health systems with better financial and clinical results are those with a greater focus on primary health care, thus enhancing the sustainability of

the entire health system [40] [41] [42] [43]. Thus, an essential part of medical errors and consequent health burdens can be prevented at the stage of primary care [44].

According to a 2018 review of primary care quality [25], different healthcare strategies are leading to improve primary healthcare quality, represented in Figure 1. 3. Globally, 72% of strategies targeted the micro level or interventions aim to directly influence the staff's performance or the facility's operations. Macro-level strategies are best able to directly tackle the social, political, economic, and organisational structures that shape a health system, which count around 25%. Meso level accounts for about 3%, and interventions address quality of care through coordinating and managing a network of facilities and communities. Interventions at this level are also well-positioned to improve communication and learning between facilities and across levels of the health system.

Figure 1. 3 Types of interventions and levels targeted to improve the quality of primary health care according to published literature from 2008 to 2017



Source: Elaborated by author, data used from the study [25]

We cannot ignore that the critical objective of a health system is to improve the health of patients and populations. However, few health systems routinely ask patients about the outcomes and the experience of their care [26] [45] [46]. Thereby, it is expected to

focus more on patient-reported outcomes and experiences as a deeper understanding of the quality of care requires measuring what matters to people. However, few health systems routinely ask patients about the outcomes and experiences of their care. Alongside a difference to evidence-based medicine, timely care is critical [26].

In the next section, a study of the financial approach is provided.

1.2.2. Financial burden

Achieving access end quality goals depends critically on sufficient health spending. Health spending pays for health workers to provide needed care and the goods and services required to prevent and treat illness. However, there is room in current health care systems functioning how to spend wisely to maximise value for money.

One of healthcare's main financial concerns is that the health sector expands faster than the rest of the economy [47]. The most recent health spending data confirm the trend of fast growth [48]. In the nearest future, this difference will lead to a financial gap of $20–54 billion per year till 2030 [5].

In addition, many studies are questioning the determination of existing health care payment systems. Some of them [6] demonstrate the inconsistency of national insurance coverage. We argue that employer contributions as a source of health financing are incompatible with universal coverage, quality of services, and rising life expectancy. Another [49] adverse selection in health insurance markets leads to two inefficiencies. On the demand side, adverse selection leads to plan price distortions resulting in inefficient sorting of consumers across health plans. On the supply side, adverse selection incentivises plans to distort benefits to attract profitable enrolees inefficiently.

Another concern to study is the common tendency of the countries to spend financial resources mostly to maintain existing health infrastructures and less to invest in new, more sustainable solutions. For instance, around 75% of the health systems budget is the costs of the health workforce and infrastructure (including medical equipment) [8]. Thus, the investment in innovative solutions that can provide strategic improvements is less than a quarter of the budget [48].

The need to move from reactive to proactive health care financial policy also demonstrates in the report OECD about the Fiscal sustainability of health systems [50]. Among others, three potential leverages are highlighted for governments that can lead to greater sustainability of health care spending without compromising significant achievements in access and quality of health care. These are information system improvement, coordination at all levels of the health care system and efficient policies as supply and demand-side, public management, coordination and financial and revenue policies.

That is why governments, in order to diagnose fiscal sustainability challenges, need information about health care spending, funding resources and other important indicators that can influence decisions related to financial sources, management or service provision. Nevertheless, in some countries, information on actual spending can take up to two years to be reported to the finance ministry.

Political and institutional factors can play a significant role in promoting the intrinsic sustainability of health systems. These factors include political agreement on the need to control health expenditure growth and specific targets; effective co-ordination mechanisms among the different stakeholders; the degree of decentralisation of health services (in terms of functions and revenues); and the boundaries between public and private spending on health. While these supportive factors can be influenced in the medium to long term, they are more difficult to change in the short term, and their absence can be interpreted as risks to the fiscal sustainability of health systems.

1.2.3. Price-related policies

Pharmaceuticals account for a significant share of overall health care spending across OECD countries. On average, one out of every five health dollars purchases pharmaceuticals when hospital use is included. Over the past few years, the consumption of pharmaceuticals has increased dramatically due to population ageing, the growing prevalence of chronic diseases and changes in clinical practices. The patterns of pharmaceutical spending growth (components of growth and underlying drivers) differ widely across therapeutic classes and countries. The respective roles of individual factors in overall spending on drugs are not easy to disentangle. However, the

most critical determinants of spending in recent years seem to be: an increase in demand for pharmaceuticals, patent expiries of essential products; and cost-containment policies in many OECD countries [51].

Pharmaceutical coverage is also typically less comprehensive than inpatient and outpatient care: across the OECD, around 57% of pharmaceutical costs are covered by government or compulsory insurance schemes. This share is less than 40% in Lithuania, Iceland, Poland, Canada and Latvia. Coverage is most generous in Germany (84%), followed by France (80%) and Ireland (78%). Over-the- counter medications –not usually covered by public schemes – play an essential role in some countries.

The increased use of generics has generated cost savings, although generics only represent around half the volume of pharmaceuticals sold across OECD countries. Increases in this surgery, lower hospitalisation rates, and shorter stays may also indicate a more efficient use of expensive hospital resources.

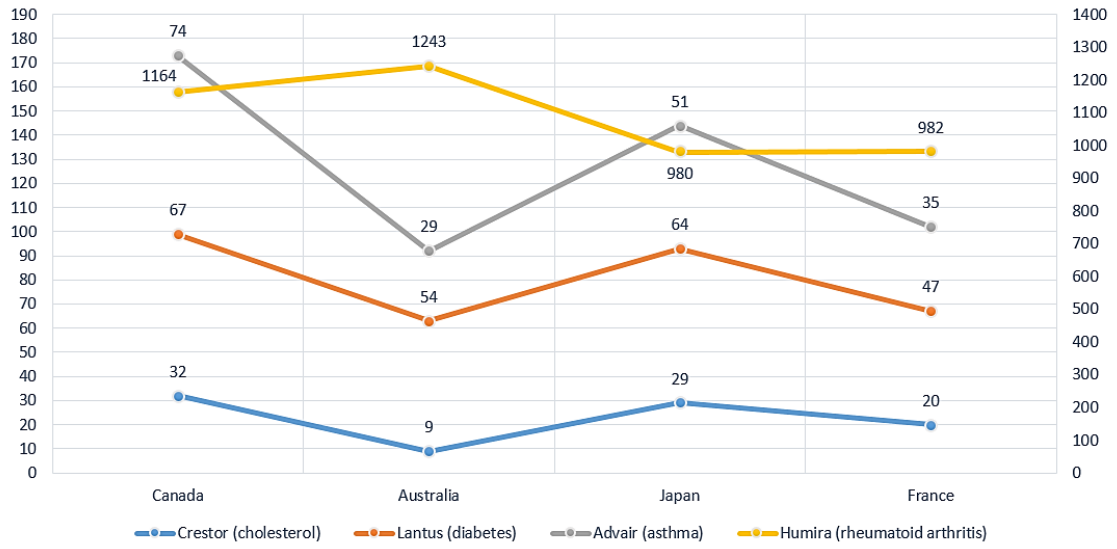
However, comparing the prices of some medicines for chronic diseases (Figure 1. 4) shows how the price for the same medicine can vary. Canada, the country with the highest share of generics and the most balanced market in terms of financing, has significantly higher prices than Japan, Australia and France.

The United States and Switzerland have significantly higher healthcare expenditures than other countries, and recently some evidence was found that pharmaceuticals prices disparities might be the reason [52][53].

1.2.4. Management

The cost of healthcare represents an increasing weight of GDP, and its sustainability in the medium term is being questioned. How can healthcare costs be reduced while causing the least possible harm to patients and healthcare personnel? The only way to provide a better service with a considerable reduction in costs is by improving the internal efficiency of healthcare organizations through tools such as efficient management [54].

Figure 1. 4 Comparison of pharmaceutical prices, USD per mo



Source: Elaborated by the author, data used from the study [52]

Recent evidence suggests that the quality of management is an essential driver of system performance [55]. Managers operate in different contexts and institutions, including purchasing organizations (for example, regional health care authorities and sickness funds) or provider organizations (for example, hospitals and physician networks). While the specific tasks differ between contexts, we believe that management is essentially about making decisions within the scope and remit the manager enjoys through his position in the system hierarchy. Decision-making is clearly, a process that is not exclusive to management.

It is essential to realize that managers have a different, and precisely a narrower, view of efficiency than policymakers. For managers and policymakers, efficiency involves balancing inputs and outputs, but managers operate in a much more constrained environment. The manager of a hospital or insurer has virtually no ability to control demand.

Nowadays, there is an extensive list of managerial problems and their consequences. Among the most frequent: are failures of care coordination, administrative complexity, fraud and abuse, overuse of resources [56], and weak education of human resources [57].

Delays in obtaining healthcare appointments are another consequence of unperfect management that lead to patient dissatisfaction, higher costs, and possible adverse clinical consequences. Longitudinal studies confirm that delayed access to care is associated with worse outcomes. Also contributing to higher costs are patients who have appointments but fail to show up for them. One clinic documented 14,000 missed appointments annually, causing estimated losses of over $1 million. No-shows are a practical consideration in clinic operations, where they interrupt the flow of patient care and reduce clinic productivity. Another study estimated that revenue shortfalls could constitute 3–14% of clinic income. These two factors emphasize the importance of appropriate scheduling and resource allocation to meet healthcare demand [58].

Another study discovered that the orthopaedic outpatient pathways through radiology usually suffer from inefficiency and low staff morale and require improvement [59].

Mistrust about the correct management of the supply process of medical supplies for surgical activity is another frequent issue among hospitals. This mistrust is produced by nursing towards the logistics people and vice versa, generating an uncomfortable and tense environment that causes repetitive checks, unnecessary checks and delegation of responsibilities. That is to say, a series of tasks that do not add added value but contribute to dissatisfaction both on the part of Logistics and the client, which in this case are those working in the surgical area [60].

A review of the literature on healthcare quality demonstrates the inherent complexity of quality in the healthcare industry, which makes the healthcare industry unique in terms of how quality management practices should be implemented. First, providing a specific treatment path for each patient, along with the heterogeneity of customers (patients), requires a high level of customized care that increases complexity in the quality of care. Second, the knowledge asymmetry (knowledge gap) between the healthcare provider and the patient adds to the complexity of the entire healthcare process. While healthcare organizations have tried to manage this complexity by engaging patients and their families, it adds complexity to healthcare delivery and ensures healthcare quality. Third, compared to other industries, customers (the patients) and the organizations (healthcare providers) are exposed to high risks and

costs associated with services performed, where the cost of failure is high. Fourth, healthcare organizations should operate under specific regulatory procedures and protocols to ensure high-quality experiences for customers. Finally, unlike other industries, service delivery could happen over a longer time horizon. It may involve different treatments, impacting customers' perception of the quality of care in the healthcare industry [55].

However, when the technical system (the delivery system) required more resources, the characteristic response of physicians and other health professionals was to press politicians for more funding for the health care system. Within this dialogue, very little attention was paid to the effectiveness or efficiency of healthcare processes: more specifically, clinicians focus on the individual patient, the effectiveness of the care, and evidence-based practices with little attention to cost control.

Indeed, significant contributors to efficiency are policy instruments that directly target patient behaviours, such as insurance coverage and cost-sharing and those that directly target physician behaviours, such as physician payment methods. From the policymaker's perspective, changes in cost-sharing arrangements or physician remuneration are politically more straightforward to implement than changes to the foundational financing structure of the system [61].

Thus, professionals were to press politicians for more funding for the health care system rather than for the effectiveness or efficiency improvements of health care processes, and policymakers accepted this approach as it is politically easier.

However, addressing managerial and sustainability issues requires a vision oriented toward the entire population and greater attention to allocative efficiency and cost control [62].

For example, the study [63] observes that the number of hospitals, beds, and doctors will naturally increase in the coming future due to increasing healthcare demands. However, this natural increment will spill over the effect on healthcare waste generation, which must be proactively managed. Therefore, some managerial interventions are required. In light of this backdrop, it is suggested that hospital

administrators and healthcare executives should be proactive in human resource planning, recruitment, and designing training programs in the area of healthcare waste management through which effective results can be achieved. Consequently, human health and the environment can be sustained for a time.

In order to improve management is essential to have data, clear indicators to measure fundamental performance advances, practical management tools, and solid healthcare management literacy. When used appropriately, efficiency indicators can be essential tools to help decision-makers determine whether resources are allocated optimally and to pinpoint which parts of the health system are not performing as well as they should be.

To sum up, rising healthcare costs, driven by population growth, demographic shifts and advances in medical technology, put the focus on cost analysis and management because cost information underpins decisions on resource allocation and effectiveness at system and organizational levels for providers, purchasers and regulators globally [64].

1.2.5. Health care data

Any previously named healthcare system vulnerabilities cannot be solved without reliable data.

Evidence shows that existing technologies based on extensive data reuse improve healthcare systems' efficiency at all levels. For example, computerized order entry helps prescribers, pharmacists, and nurses distribute medications to reduce adverse drug events. Unfortunately, only about one-third of hospitals have these systems, and even fewer use barcode medicine administration to decrease medication errors [65]. Studies have suggested that computerized provider order entry systems could reduce medical errors by approximately 50%. Clinicians completing orders should have distraction-free locations to optimize this potential [30].

Prevention actions to decrease errors in information technology include: automating dispensing devices, barcoding, computerizing the medication administration record, computerizing order entry and decision support, intercepting error messages at the time

medications are ordered, prompt warnings for drug interaction, allergy, or overdose, providing drug-specific information, filling prescriptions using robotics, providing up-to-date information on new drugs, etc.

Despite optimistic predictions of the positive contribution of healthcare extensive data reuse, nowadays, healthcare is not ready for Big Data implementation due to a variety of reasons ranging from a lack of interest from physicians, a healthcare culture not accustomed to using data, threats to patient safety, healthcare data quality issues, privacy-related issues, and Big Data failures [66] [67].

Numerous barriers are perceived by physicians, medical staff, and scholars, who communicate why many medical institutions have failed to adopt extensive data medical systems. All barriers are related to human expertise, resource allocation, operational procedure, laws and regulations, and market access capability. Unless medical institutions withdraw these barriers, adopting extensive data systems is impossible. The research findings also show that managers should consider the identified barriers' importance-driven sequence to follow the most direct and expedient pathway when solving development problems [68].

The lack of interoperability, quality and use of health information, and socio-economic inefficiencies causes medical errors in treatment, omission, communication, context and diagnosis. The cost of these, only in the United States, fluctuates between 98,000 and 400,000 fatalities annually. This number is presumably much higher globally [28].

Recently, the European Commission found that the annual cost of not having research data findable, accessible, interoperable and reusable costs the European economy at least € 10.2 billion each year [69].

Electronic records often decrease clinician efficiency. While electronic health records (EHR) provide more clearly written information, they also may facilitate charting information on the wrong patient. Currently, there are no regulatory agreed-upon design standards that successfully limit potential errors [37].

In addition, clinicians report that the computer comes between them and the patient, creating constant distractions. Often EHRs are designed to be addictive, and it may be impossible to correct prior errors. This can lead a clinician to propagate incorrect information forward.

With the deployment of electronic records, three phases of medical malpractice risk have been recognized and include the following:

1. Implementation phase. During this phase, practitioners acquire new skills and learn a novel system. Thus, lack of or inadequate training with implementation during this phase leads to new errors.

2. Transition phase. When moving from a paper record or one computerized system to another, records can be misplaced or incorrectly added to a patient's record.

3. Mature phase. System-wide failures, such as server errors or intranet failures, may create chaos and interfere with documentation [30].

Recent researches suggest that researchers should anticipate the problem of engendering compliance and healthy behaviour in chronic disease care since the problems that patients face during their disease tend to change over time [70].

The recommendation system should not only support decision-making and avert dangers and failures but also monitor patients, dispense treatment as necessary, keep track of vital signs, and communicate via a centralized server in real-time. This increases the suitability of health recommendation systems [71].

In addition, new healthcare big data strategies are needed to improve healthcare services and rearrange healthcare expenditure systems. As it was mentioned previously, there are important questions regarding the stewardship responsibilities of governments and regulators in terms of the costing approach due to the prevalence of tariff setting approach based on diagnosis-related groups (DRG), in contrast to many other industries, detailed product or service costing is regulated, collected by government and sometimes publicly reported.

As seen today, healthcare systems are challenged to generate insights and evidence from real-world clinical data at scale to support patients, clinicians, payers, regulators, governments, and the pharmaceutical industry in understanding wellbeing, disease, treatments, outcomes and new therapeutics and devices. Unfortunately, such data is challenging to use in many languages, systems and structures at scale, with challenging policy restrictions and technology considerations. Consequently, using real-world data for research, reflective of what happens for patients in their own healthcare experience, is very challenging. Every day, patients are suffering or dying because we cannot tap into the transformational potential of real-world data.

Health systems must adapt to future threats; constant innovation is one way to do so. First of all, because of the disease burdens, and second because of the possibility of technology, and they are new models of care involving changing professional roles and advances in communication and data processing increasingly informed by evidence from health services research. In addition, the Health sector's propensity to innovate has also been explained by the characteristics of the individuals involved in their organisations and the context.

To conclude, actions to tackle waste are needed in the delivery of care, in the management of health services, and in the governance of healthcare systems. Strategies include stopping spending on actions that do not result in value – for example, inefficient surgeries and clinical procedures. Swapping inputs or changing approaches when equivalent but less pricy alternatives of equal value exist are good strategies, too – encouraging generic drugs, developing advanced roles for nurses, or ensuring that patients who do not require hospital care are treated in less resource-consuming settings.

Of course, this agenda is complex and difficult. Change requires challenging embedded habits and vested interests and investing in credible alternatives to costly solutions. Crucially, it also requires the development of better, more appropriate data systems to monitor progress. Patients, providers, managers and regulators all play a role in generating waste and inefficient spending. With as much as 10% of GDP spent on health care systems across the OECD, the central part governments make, all stakeholders must

now contribute to the solution. The evidence of waste in health care is indisputable. Now is the time to act upon it [27].

In the next section, the objectives of the thesis will be clarified.

1.3. Objectives and contributions

"Increasing health expenditures and healthcare facilities will not guarantee better performance in healthcare [72]."

We observed that healthcare systems were formed relatively recently. During the last 60 years, life expectancy at birth was improved by 20 years at the world level. Nowadays, the development of health care is mainly led by the 2030 Sustainable Health Goal number 3, which consists of providing universal health care coverage in all income countries groups. However, due to the pandemic COVID 19, the objectives were strengthened with additional regional programs with much more complex challenges, primarily based on efficiency, value and sustainability principles.

It was recognized that there are many more reasons to focus on new policies of healthcare systems development in addition to rising healthcare problems burden related to population ageing and the threat of financial unsustainability. Those are poor-quality health care services, preventable medical errors, lame financial and price policies, intuitive management, unused assets such as health care data and population illiteracy about health care.

Thereby, demographic change, rising chronic disease and multimorbidity, fiscal pressures and a wide range of determined inefficiencies are challenging healthcare systems' medium- and long-term sustainability worldwide. This is why a strategic movement from volume to value is needed. By volume, we can characterize the continuously growing healthcare expenditure as a critical response to the range of spending determinants. At the same time, value means healthcare efficiency or a relationship between the results and the costs when healthcare performance is attained

in the best possible manner, which involves the minimum waste of time and effort maintaining quality standards.

In this work, we intend to investigate the concept of healthcare efficiency at macro and micro levels to contribute to the sustainability of modern healthcare systems. To address this aim, three research subjects were formulated.

1) The relationship between Life expectancy at birth and Health care expenditure

The relationship between Life expectancy at birth and Health care expenditure is complex, and the evidence is inconclusive. This study analyses the relationship between Life expectancy at birth and Health care expenditure, distinguishing between different financial schemes. We further emphasize the relevance of macroeconomic, social, and institutional quality in shaping Life expectancy at birth (LEB).

In this part of the investigation, we try to answer the following research questions:

a) Does the volume of healthcare expenditures affect LEB?
b) Does the financial scheme define the LEB?
c) What are the macroeconomic and social determinants of LEB?
d) Does institutional quality impact LEB?

2) Healthcare expenditures disparities among high-income countries

High-income countries show some relatively essential differences both in their levels of healthcare expenditures and in their health outputs, such as life expectancy at birth. This study aims to analyse whether those disparities in health results are just derived from divergent levels of health expenditure or depend on other factors, not all directly related to health activities. We try to find ways to improve health outputs besides rising health expenditure.

The research questions we aim to answer in this study are:

a) Why do healthcare expenditure disparities exist among countries with similar income levels?

b) What are the determinants of health care results of highly efficient health care systems?

3) The efficiency of health care as a strategic management

Addressing managerial and sustainability issues requires a vision oriented towards the entire population and greater attention to allocative efficiency and cost control. This study proposes a conceptual framework to guide healthcare policymakers and managers in implementing healthcare efficiency. We aim to develop a tool for administrators that will help them manage the upcoming healthcare sector needs. Accordingly, we apply this framework to a real case. More specifically, we apply it to the surgical area of a medium-sized Spanish hospital.

The research questions of this part of the study are:

a) Who is responsible for the efficiency of the healthcare system?
b) Is it possible to define efficiency implementation as a strategy?
c) What methodology may be used as a base for the implementation of healthcare efficiency?
d) What would be a conceptual framework of the strategy of health care efficiency implementation?
e) Does it work on a real case study?

1.4. PhD thesis structure and contributions

The dissertation is structured according to the areas of investigation mentioned before.

In the second chapter, we investigate the impact of healthcare expenditure volume and scheme on healthcare results. We also analyse additional determinants of Life expectancy at birth among social, economic and institutional quality indicators to determine additional leverages of action for policies devoted to improving health care. We are using cross-country data from 138 countries from 2000-2018. The results showed that some of the analysed determinants are positively and significantly correlated with macro-level healthcare outputs. Thus we will continue using them in the subsequent investigation.

The third chapter of the thesis describes the study centred on high-income countries due to the remarkable disparity of the health care expenditures they have despite similar outcomes. We analysed 27 countries in the 2000-2019 period. Moreover, they used the determinants of LEB defined in the previous study and other variables suggested by the state of the art.

By analysing HCE's cross-sectional drivers, we aimed to find the reasons for existing disparities in HCE among countries with similar socio-economic situations and healthcare outputs. We found discrepancies in defining vias to improve health care efficiency in those countries that spend more and have the same results. Also, to provide for high-income countries, the focus is on the most relevant determinants to improve healthcare efficiency.

Chapter four includes the micro-level study focused on the actual case of a Spanish hospital. In this part of the thesis, we contribute by suggesting a conceptual framework of health care system efficiency implementation as a strategy based on the Project Management Institute standard of Program Management Professionals. After being practically tested, we can suggest it as a managerial tool to develop a new practical perspective on healthcare efficiency.

The last chapter of the thesis gathers the investigation's conclusions by answering the research questions described previously.

2. BEYOND HEALTHCARE EXPENDITURE. THE LINK BETWEEN SOCIOECONOMIC, INSTITUTIONAL FACTORS AND LIFE EXPECTANCY AT BIRTH

This investigation explores the link between socioeconomic and institutional factors and health outcomes, proxied by life expectance at birth. The main goal is to highlight the association between factors other than healthcare expenditure and health outcomes. We estimate linear regression and panel data models using data on a large set of countries and years. Rather interestingly, our results indicate that social and government quality conditions are as essential drivers of health as financial and economic factors.

2.1. Introduction

Both public health policies and the quality of care have undoubtedly improved over the last decades, contributing to steady increases in Life expectancy at birth (hereafter, LEB). The latter has been usually linked to a worldwide increase in health care expenditure (hereafter, HCE) both per capita and as a percentage of GDP.

However, the 2008 economic crisis led to a worldwide fall in healthcare expenditure. This has triggered more vital concerns about efficiency. As a result, a wide range of initiatives to increase efficiency in public spending on health has been introduced, such as reductions in hospital stay length and administrative costs. These changes are compatible with maintaining LEB only if health systems improve their efficiency at managing resources that deliver better health outcomes [73].

Looking ahead, more pressure on health systems is expected to arise from population ageing, the rise of chronic diseases and multimorbidity, and the fiscal burden that limits further increases in HCE. All these factors pose a challenge to the medium- and long-term sustainability of health systems [74], which requires an increase in the effectiveness and efficiency of health systems.

Recently, a significant scientific effort has been made to discover the main leverages of healthcare outputs in healthcare systems. Special attention has been devoted to

investigating the relationship between the volume of investment in health care and health outputs, which are commonly proxied by Life expectancy at birth and mortality indicators.

A significant relationship between HCE and mortality has been found in previous studies [3-7], They consequently argue that health government spending is as important as economic growth in contributing to health outputs. Besides, they point out that expansions in health system coverage through higher publicly pooled spending lead, on average, to improvements in population health, measured by lower child and adult mortality rates [76] [77] and higher LEB [78].

The potentially positive influence of HCE on economic growth and vice versa also received attention from multiple researchers. Several studies find that HCE boosts economic development [10–13]. Conversely, the investigation of the relationship between Gross Domestic Product and HCE reports a causal dependence, i.e. as income rises, people will choose relatively more HCE [83].

There also exists a social approach to the HCE-LEB relationship. It encourages policymakers to invest primarily in education and programs devoted to handling capacity problems and delivering equal financial access to medical care by the population [15–17]. Political stability, good governance and education enrolment are among the leading social determinants of LEB [87] [88].

A recent study highlights the relevance of accounting for the quality of institutions and governance to provide efficient healthcare financing [89]. It also suggests relying on pluralistic health care systems (HCS) systems to balance sustainability and equilibrate the distribution of resources across the functions of the public welfare system [90]. Other authors conclude that countries striving to improve their HCS efficiency should aim to affect population behaviour and welfare rather than only ensure adequate medical care [91].

The extant literature underlines that health care outcomes (i.e., LEB) have many multidimensional determinants. Thus, besides medical care, healthcare expenditures volume, type of the Health Care System, social and economic conditions, or even the

quality of the institutions are also related to healthcare outcomes. Besides, the relationship between them is complex. Previous research using different study designs and methods [92] has obtained different and sometimes contradictory results [93] [94].

Consequently, our work contributes to the extant literature by further examining the determinants of LEB. Specifically, we analyse the relationship between LEB and Health care expenditure indicators, taking into account the existence of alternative financial schemes. By doing so, we aim to check the relevance of the investment volume to the output and to examine if a different distribution of health expenditure among those different schemes affects that output. More crucially, we analyse a comprehensive set of socio-economic variables and institutional quality indicators to determine additional leverages of action for policies that improve health care.

To our knowledge, this is the first study to jointly evaluate the strength of the relationship between HCE, macroeconomic, socioeconomic, and institutional indicators and LEB using a cross-country analysis from 2000-2018.

The rest of this chapter is organized as follows. Section 2 describes the data and methodology used in the investigation. The results are presented in section 3. Section 4 discusses the implications of the main results, and finally, section 5 concludes.

2.2. Data and Methods

This paper uses annual country-level data for 138 countries over the period 2000-2018 to analyse the association of LEB with HCE volumes and types and with economic, social, and institutional quality indicators. Table 2. 1 provides variable definitions and data sources.

Table 2. 1 Definition of variables and data sources

	Abbreviation	Description	Source
Health outcomes			
Life expectancy at birth	leb	total years	WDB[1]
Healthcare expenditure			
Health care expenditure by Government schemes (HF1.1) of Total HCE	govhce	% of total HCE	WHO[2]
Health care expenditure by Compulsory contribution schemes (HF1.2) of Total HCE	comphce	% of total HCE	WHO
Health care expenditure by Voluntary payment scheme (HF2) of Total HCE	volhce	% of total HCE	WHO
Health care expenditure by Out-of-pocket schemes (HF3) of Total HCE	ophce	% of total HCE	WHO
Healthcare expenditure per capita	thcepc	International $ (PPP)	WHO
Economic variables			
Real GDP growth	gdpgr	annual %	WDB
Inflation	infl	GDP deflator (annual %)	WDB
Central government debt	cgd	% of GDP	WDB
Countries aggrupation by income: Low income	inc_clas1	countries' aggrupation by income	WDB
Countries aggrupation by income: Low middle income	inc_clas2	countries' aggrupation by income	WDB
Countries aggrupation by income: Upper middle income	inc_clas3	countries' aggrupation by income	WDB
Countries aggrupation by income: High income	inc_clas4	countries' aggrupation by income	WDB
World Government Indicator			
Government effectiveness	wgige	-2.5 (weak) to 2.5 (strong) governance performance	WDB
Social variables			
Human Capital Index	hc	from 0 to infinite potential	WDB
Unemployment rate	ur	annual, age 15-65, percentage	WDB
Gini Index	gini	0 (perfect equality) to 100 (perfect inequality)	WDB
Population density	popden	people per sq. Km	WDB

[1]World Data Bank

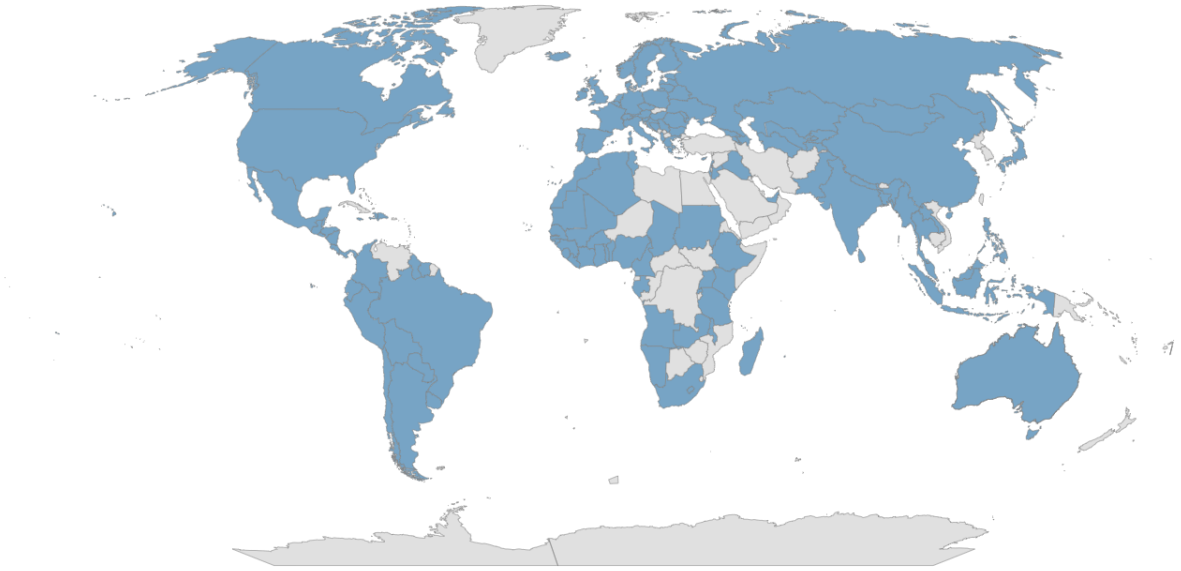
[2]World Health Organization

The goal is to assess the role of several factors that are associated with improvements of healthcare efficiency in delivering good and financially sustainable outcomes, which is deemed essential nowadays. The dependent variable to proxy Health outcome is Life expectancy at birth (LEB). The explanatory variables are split into four groups: healthcare expenditure, economic variables, an indicator of institutional performance, and social variables. Table 2. 2 displays summary statistics for the main variables used in the analysis.

We also cluster countries into four groups by income levels according to the World Data Bank classification: High, Upper middle, Low middle and Low income [95]. Table 2. 3 summarizes each group of countries' mean value of the explanatory variables.

Due to data consistency and availability, we restrict attention to 138 countries from 2000 to 2018. Figure 2. 1 shows the selected countries included in the analysis (the list is available in APPENDIX I Table A. 1). Hence, we primarily work with original/raw data from different sources. Only one variable has missing values, and Table A. 2 Example of the calculation of missing value for Gini indexin APPENDIX I explains the procedure for dealing with them.

Figure 2. 1 World map with selected countries



Source: Elaborated by the author

Table 2. 2 Summary statistics (2000-2018; 138 countries)

Variables	# obs	Mean	Std. Dev	Min	Max
Health outcomes					
Life expectancy at birth, total years	3078	69.5	9.02	39.4	84.2
Health care expenditure					
Health care expenditure by Government schemes (HF1.1) of Total HCE, % of total HCE	3054	38.5	23.6	.01	97.1
Health care expenditure by Compulsory contribution schemes (HF1.2) of Total HCE, % of total HCE	3057	15.1	22.7	0	84.0
Health care expenditure by Voluntary payment scheme (HF2) of Total HCE, % of total HCE	3054	10.8	11.2	0	78.5
Health care expenditure by Out-of-pocket schemes (HF3) of Total HCE, % of total HCE	3057	34.9	19.8	.1	86.1
Healthcare expenditure per capita, international $ (PPP)	3060	1121.3	1510.6	6.6	12642.8
Economic variables					
Real GDP growth, annual %	3047	4.01	5.1	-62.1	123.1
Inflation, GDP deflator (annual %)	3048	6.9	13.1	-36.5	418.0
Central government debt, % of GDP	3005	51.6	44.2	.3	593.7
World Government Indicator					
Government effectiveness, -2.5 (weak) to 2.5 (strong) governance performance	3076	-.04	.9	-2.3	2.4
Social variables					
Human Capital Index, from 0 to infinite potential	2508	2.5	.7	1.1	4.2
The unemployment rate, annual, age 15-65, Percentage	3021	7.5	5.4	.1	35.3
Gini Index, 0 (perfect equality) to 1 (perfect inequality)	2843	39.1	8.1	12.6	64.8
Population density, people per sq. Km	3067	176.3	583.5	1.5	7952.9

Table 2. 3 Mean value of explanatory variables by income group countries (2000-2018; 138 countries)

	Low	**Low-middle**	**Upper-middle**	**High**
	Mean	*Mean*	*Mean*	*Mean*
Health outcomes				
Life expectancy at birth, total years	59.0	68.2	71.9	78.7
Health care expenditure				
Health care expenditure by Government schemes (HF1.1) of Total HCE, % of total HCE	31.7	39.4	35.9	46.2
Health care expenditure by Compulsory contribution schemes (HF1.2) of Total HCE, % of total HCE	5.8	11.1	20.4	23.6
Health care expenditure by Voluntary payment scheme (HF2) of Total HCE, % of total HCE	16.3	9.6	10.1	7.4
Health care expenditure by Out-of-pocket schemes (HF3) of Total HCE, % of total HCE	45.1	39.2	33.2	22.1
Healthcare expenditure per capita, international $ (PPP)	346.5	394.4	918.0	2821.9
Economic variables				
Real GDP growth, annual %	5.1	4.6	3.6	2.6
Inflation, GDP deflator (annual %)	10.0	8.2	6.9	2.6
Central government debt, % of GDP	66.9	44.1	45.0	51.7
World Government Indicator				
Government effectiveness, -2.5 (weak) to 2.5 (strong) governance performance	-.8	-.4	-.01	1.2
Social variables				
Human Capital Index, from 0 to infinite potential	1.6	2.2	2.7	3.1
The unemployment rate, annual, age 15-65, Percentage	5.3	8.0	10.3	6.4
Gini Index, 0 (perfect equality) to 1 (perfect inequality)	40.1	40.5	42.4	32.2
Population density, people per sq. Km	118.4	109.9	114.7	359.1

The output of health systems is usually proxied either by longevity indicators, such as Life expectancy (at birth, at 65 years, healthy life expectancy) for the total population and by gender, or by mortality indicators (mortality rate, infant mortality rate, potential years of life lost). These indicators are considered good proxies for measuring the health status of a population [96]. Following previous studies, this paper uses Life expectancy, defined as "total years lived", as a measure of health output [97].

This paper employs the Standard System of Health Accounts 2011 to define Health care expenditure by financial schemes [13]. Thus, four categories of HCE are defined as a percentage of Total Health care expenditure: Health care expenditure by Government schemes (that corresponds to HF11 code in SHA 2011), by Compulsory contribution schemes (HF1.2), by Voluntary payment scheme (HF2) and by Out-of-pocket schemes (HF3).

We also include HCE per capita in real US Dollars (in Purchasing Power Parity terms) and a set of economic variables to account for the effect of macroeconomic conditions on health outcomes. These variables include real GDP growth rate, Inflation, measured as the growth rate of GDP deflator, and General government debt as a percentage of GDP.

To account for the impact of institutional quality on health outputs, we use Government Effectiveness. It ranges from -2.5 (weak) to 2.5 (strong) governance performance [98]. As robustness checks, we have re-estimated our baseline model using alternative World Government Indicators (Voice and Accountability, Political Stability, No Violence, Regulatory Quality, Rule of Law, and Control of Corruption) and the results remain qualitatively unaltered.

We add several socioeconomic variables that affect healthcare output. Following previous studies, we include the Unemployment rate [99]. To measure how education impacts Life expectancy, we use Human Capital Index [100].

Besides, we test whether income inequality is associated with LEB through each country's Gini Index. It ranges from 0 to 100, involving perfect equality and maximum inequality in income distribution, respectively.

We also include each country's population density to assess whether the degree of spatial concentration of the population impacts LEB.

We estimated equation (1), which shows the relationship between health outcomes (proxied by life expectancy at birth, *leb*), socio-economic indicators and other control variables. Health care expenditure by Compulsory contribution is represented by *compact*, Voluntary payments and Out-of-pocket schemes by *violence* and *space* accordingly. Health care expenditure per capita is tagged as *thcepc*. *gdpgr* stands for Real GDP growth indicator, *infl* for Inflation, *cgd* for Central government debt. Government effectiveness is shown in the equation as *wgige*, Human Capital Index as *hc*, Unemployment rate as *ur*. Gini Index and Population density are represented as *gini* and *popden* respectively.

$$leb_{it} = \beta_0 + \beta_1 comphce_{it} + \beta_2 volhce_{it} + \beta_3 ophce_{it} + \beta_4 thcepc_{it} + \beta_5 gdpgr_{it} + \beta_6 infl_{it} + \beta_7 cgd_{itn-3} + \beta_8 wgige_{it} + \beta_9 hc_{it} + \beta_{10} ur_{it} + \beta_{11} gini_{it} + \beta_{12} popden_{it} + \varepsilon_{it} \quad (1)$$

Where subscripts *i* and *t* refer to country *i* in year *t*, respectively. The error term ε_{it} Captures unobservable variables and random noise.

We start with estimating equation (1) by ordinary least squares (OLS, hereafter) using data on 138 countries from 2000 to 2018. However, some potential limitations arise related to the possibility of reverse causality or simultaneity in the relationship between our variable of interest and health outcomes. In this pooled OLS estimation, a related concern is that there may also be unobservable variables that correlate with our main explanatory variables and the health outcome. As a result, we could obtain biased estimated coefficients.

We can further decompose the error term in equation (1) in the following three components that may account for different sources of endogeneity:

$$\varepsilon_{it} = \propto_i + \delta_t + u_{it} \quad (2)$$

Where $\propto_i$ is a country-specific effect that captures time-invariant unobservable factors potentially correlated with the explanatory variables and life expectancy at birth in a

given country. The term δ_t is a period-specific shifter that simultaneously captures aggregate shocks affecting health outcomes in all countries. If all potential sources of endogeneity are accounted for by these two components of the error term, then u_{it} is a random, idiosyncratic error component.

To deal with the problem of omitted variables, we take advantage of the panel dimension of the dataset. That is, we observe many countries over a long-time span. Thus, we carry out a pooled OLS estimation with year and country fixed effects and a fixed effects panel data estimation.[2] By doing so, we account for the effect of time-invariant omitted variables at the country level. Moreover, we estimate the model with one-year lagged explanatory variables to mitigate endogeneity concerns related to the simultaneity between the health outcome and the explanatory variables (namely, socioeconomic indicators).

Table 2. 4 presents the correlation across variables and the expected relationship between the explanatory variables and LEB. We expect a positive association of healthcare investment with LEB. Following previous studies, we also anticipate a positive relationship between Government and Compulsory contribution schemes and LEB. Conversely, we expect an adverse effect of the out-of-pocket scheme because the low-income population, particularly in poor countries, cannot afford to pay for their health care services [101].

We anticipate a negative association between real GDP growth and Life expectancy. Emerging and developing countries usually enjoy a higher growth rate than developed countries with higher LEB. Regarding the rest of the macroeconomic variables, we predict a negative association with LEB of inflation and government debt because the reduction of real purchasing power and increased resources devoted to paying interest on the public debt may hurt LEB. These adverse effects are probably more vital for low-income countries, which usually face higher inflation rates and more difficulties (both in terms of availability and cost) in financing public debt.

[2] We carry out a Hausman test that leads to reject the random effects model vs fixed effects model.

Table 2. 4 Bivariate correlations and expected relationships between LEB and explanatory variables

		Bivariate Correlation	Hypothesis
Health care expenditure			
Health care expenditure by Government schemes (HF1.1) of Total HCE	govhce	0.94	Omitted category
Health care expenditure by Compulsory contribution schemes (HF1.2) of Total HCE	comphce	0.265	$B_1>0$
Health care expenditure by Voluntary payment scheme (HF2) of Total HCE	volhce	-0.224	$B_2<0$
Health care expenditure by Out-of-pocket schemes (HF3) of Total HCE	ophce	-0.299	$B_3<0$
Health care expenditure per capita	thcepc	0.495	$B_4>0$
Economic variables			
Real GDP growth	gdpgr	-0.208	$B_5<0$
Inflation	infl	-0.229	$B_6<0$
Central government debt	cgd	-0.059	$B_7<0$
World Government Indicator			
Government Effectiveness	wgige	0.710	$B_8>0$
Social variables			
Human Capital Index	hc	0.428	$B_9>0$
Unemployment rate	ur	0.020	$B_{10}<0$
Gini index	gini	-0.359	$B_{11}<0$
Population density	popden	0.182	$B_{12}=?$

Besides, a positive relationship between the quality of institutions and LEB is likely to occur. This variable is proxied by the Government's Effectiveness, and the coefficient captures its effect β_8 in equation (1) and represents an essential contribution to this work.

As for social variables, we expect a positive effect of the capital index, given that more educated citizens are more likely to evaluate the need to use healthcare services and a more robust demand for improvements in those services. Conversely, we expect an adverse effect on the Unemployment rate [102]. For the Gini Index, a low-income level, both absolute (associated with an unemployment situation) and relative (due to a high inequality distribution), is expected to affect LEB adversely.

Furthermore, we do not have a precise prediction of the impact of a country's population density on LEB. On the one hand, a higher density may provoke congestion lowering health quality services (e.g., to tackle epidemic processes). On the other hand, a more dispersed population may make the provision of both primary and emergency health services more difficult or force authorities to increase the financial resources used for the same level of health care.

Finally, the countries' income levels might shape the relationship between some explanatory variables and health outcomes. To account for this, we estimate separate regressions for the relevant income groups.

2.3. Results

Columns (1)-(4) of Table 2. 5 display the results from the estimations of several specifications of pooled linear regression models, whilst columns (5)-(6) present panel data estimates of equation (1). The main difference across columns is related to (i) the inclusion of a set of year and country-level fixed effects that aim to account for different sources of bias, namely business cycle and country-specific and time-invariant factors, that may affect the results of column (1); and (ii) the inclusion of one-year lagged explanatory variables to mitigate endogeneity concerns arising from simultaneity between the dependent and the explanatory variables.

Table 2. 5 OLS and Panel data estimates (138 countries, 2000-2018)

	OLS estimates				Panel data estimates	
	(1)	**(2)**	**(3)**	**(4)**	**(5)**	**(6)**
Health Care Expenditure						
Compulsory spending, % of total HCE	-0.008	-0.038	-0.008	-0.038	-0.040	-0.038
	(0.005)	(0.006)***	(0.005)	(0.006)***	(0.009)***	(0.008)***
Voluntary spending, % of total HCE	-0.031	0.017	-0.028	0.021	0.013	0.021
	(0.011)***	(0.010)*	(0.011)**	(0.010)**	(0.008)*	(0.007)***
Out-of-pocket spending, % of total HCE	0.059	-0.017	0.058	-0.018	-0.036	-0.018
	(0.009)***	(0.006)***	(0.009)***	(0.006)***	(0.006)***	(0.005)***
Health spending per capita, international $ (PPP)	1.372	-0.002	1.392	0.102	2.615	0.102
	(0.147)***	(0.218)	(0.149)***	(0.222)	(0.140)***	(0.166)
Economic Variables						
Real GDP growth, annual %	-0.124	-0.010	-0.111	-0.007	-0.013	-0.007
	(0.040)***	(0.014)	(0.039)***	(0.014)	(0.009)	(0.009)
The inflation rate, GDP deflator (annual %)	-0.040	-0.011	-0.039	-0.010	-0.013	-0.010
	(0.012)***	(0.003)***	(0.012)***	(0.003)***	(0.003)***	(0.003)***
Government debt, % of GDP	-0.005	-0.013	-0.006	-0.012	-0.012	-0.012
	(0.004)	(0.002)***	(0.004)	(0.002)***	(0.001)***	(0.001)***
World Government Indicator						
Government effectiveness, -2.5 (weak) to 2.5 (strong) governance performance	2.677	0.978	2.658	0.858	0.486	0.858
	(0.201)***	(0.237)***	(0.205)***	(0.230)***	(0.203)**	(0.183)***
Socio-economic variables						
Human Capital Index, from 0 to infinite potential	5.562	0.814	5.478	0.518	7.625	0.518
	(0.245)***	(0.655)	(0.249)***	(0.696)	(0.423)***	(0.478)
The unemployment rate, annual, age 15-65, Percentage	-0.139	0.016	-0.145	0.003	0.014	0.003

	(0.034)***	(0.014)	(0.035)***	(0.015)	(0.017)	(0.015)
Gini index, 0 (perfect equality) to 1 (perfect inequality)	-0.035	-0.011	-0.035	-0.009	-0.019	-0.009
	(0.018)**	(0.020)	(0.018)*	(0.020)	(0.015)	(0.014)
Population density, people per sq. Km	0.005	0.006	0.005	0.006	0.007	0.006
	(0.000)***	(0.001)***	(0.000)***	(0.001)***	(0.001)***	(0.001)***
Constant	48.466	55.781	48.827	68.273	37.056	66.739
	(1.385)***	(2.673)***	(1.385)***	(3.438)***	(1.237)***	(1.661)***
One-year lagged explanatory variables	NO	NO	YES	YES	YES	YES
Country fixed effects	NO	YES	NO	YES	FE	FE
Year fixed effects	NO	YES	NO	YES	NO	YES
N. Observations	2309	2309	2196	2196	2196	2196
log-likelihood	-7163.2	-3923.6.0	-6785.6	-3641.8	-4237.0	-3641,8
R-squared	0.674	0.980	0.674	0.981		

Notes:

The regressand is life expectancy at birth in year t. Robust standard errors in parenthesis. *** p<0.01, ** p<0.05, * p<0.1

Annual data on 138 countries over the period 2000-2018. In cols. (5) and (6), F-test indicate significant country effects exist. We carry out a Hausman Test that rejects the random effects model, so fixed effect (FE) leads to consistent estimates.

The years and country fixed effect results confirm the expected trends for the selected countries and period of time. The details are represented in APPENDIX I Table A. 3.

Several important results stand out. First, as expected, the health expenditure per capita level depicts a positive and robust association with LEB. On the other hand, no clear-cut result is consistently obtained regarding the type of health financing beyond government expenditure. Second and rather interestingly, a negative link arises between some socio-economic variables and life expectancy at birth. Namely, GDP growth, inflation, unemployment rate and Gini index are negatively related to health outcomes. Third, and notably, we obtain a positive association between government effectiveness and health that consistently holds across the different specifications. This suggests the relevance of institutional factors on health outcomes. Some explanatory variables turn non-significant as we move across columns to complete the equation (1) specifications.

The results of our baseline model suggest that income per capita levels is strongly associated with the dependent variable. We dig deeper into this relationship by carrying out an estimation including income-levels groups (not reported for brevity). Pairwise income tests across income groups confirm the existence of significant differences across all groups except for the upper-middle- and high-income groups. To further explore these differences, we estimate separate regressions by income group and the results are presented in Table 2. 6. Namely, low-, low-middle, upper-middle, and high-income country groups. We report estimates of our preferred specifications in Table 2. 5 for each of these income groups, that is, columns (5)-(6) that report fixed-effects panel data estimates of equation (1). Year-fixed effects are shown in APPENDIX I Table A. 4. The results are broadly consistent with those reported previously.

However, some interesting results when we distinguish by income groups emerge. First, the positive effect of voluntary spending is significant for low-income countries. Second, the positive association between health spending per capita and LEB mainly holds for low- and high-income countries. Third, the negative relationship between inflation and LEB holds for all income groups except low-income countries. Fourth, as expected, Government effectiveness is significant for low-income countries. Fifth, regarding

population density, our results show that the countries with low-income levels show a positive relationship between LEB and population density. Then, a more dispersed population may cause more difficult access to health care services. However, a more concentrated population may lead to congestion (and worse results) in health services or deterioration of health due to urbanization. The first effect appears more vital for the referred groups of countries, while the variable loses its explanatory ability for countries with higher income levels.

2.4. Discussion

This paper investigates the complex relationship between Life expectancy at birth as an indicator of healthcare output and Health care expenditure as a critical healthcare input. We further look at the potential explanatory role of a comprehensive set of social, economic, and institutional variables in driving LEB. To that end, we use annual cross-country data on 138 countries from 2000-2018.

As expected, countries with higher investment in their healthcare systems significantly enjoy longer Life expectancy. Besides, additional important determinants of LEB performance are uncovered. Indeed, one of them is the income level. The economic development of the countries leads to higher Life expectancy. At each subsequent level of income (low, low, middle, upper-middle and high level), LEB becomes more promising.

Another important finding is the impact of institutional quality on LEB. World Government Indicators (and their average) show a positive relationship with LEB according to OLS and Panel data estimations. Moreover, the study by income group demonstrates a strong Government Effectiveness impact, especially in Low and Low middle-income countries. The selected macroeconomic variables' results confirm our expectations, even if the impact is significant for inflation and public debt and not so much for growth. Finally, our results also dispelled doubts about the importance of social well-being for high healthcare output as LEB. For instance, education (human capital) contributes to the longer life of the population. Additionally, and reinforcing the relevance of social well-being, unemployment and income inequality significantly reduce the expected life years.

Table 2. 6 Life Expectancy at Birth and socio-economic indicators. By income groups. Panel data estimates

	Low		**Low middle**		**Upper middle**		**High**	
	Equivalent col., Table 2.5:		Equivalent col., Table 2.5:		Equivalent col., Table 2.5:		Equivalent col., Table 2.5:	
	Col (5)	Col.(6)	Col (5)	Col.(6)	Col (5)	Col.(6)	Col (5)	Col.(6)
Health Care Expenditure								
Compulsory spending, % of total HCE	-0.037	-0.039	0.020	-0.001	0.012	-0.007	-0.003	-0.006
	(0.059)	(0.028)	(0.032)	(0.011)	(0.037)	(0.020)	(0.018)	(0.006)
Voluntary spending, % of total HCE	0.043	0.059	0.067	0.003	-0.118	-0.161	0.000	0.006
	(0.036)	(0.011)***	(0.048)	(0.011)	(0.072)	(0.024)***	(0.010)	(0.004)
Out-of-pocket spending, % of total HCE	-0.017	0.040	-0.028	-0.030	-0.011	0.006	-0.004	-0.010
	(0.035)	(0.012)***	(0.021)	(0.008)***	(0.023)	(0.014)	(0.011)	(0.003)***
Health spending per capita, international $ (PPP)	3.346	1.281	3.127	-0.107	0.044	-2.692	2.264	0.843
	(0.702)***	(0.257)***	(0.805)***	(0.244)	(0.863)	(0.554)***	(0.379)***	(0.139)***
Economic Variables								
Real GDP growth, annual %	-0.006	-0.012	-0.035	-0.009	-0.029	-0.036	0.001	-0.002
	(0.019)	(0.015)	(0.022)	(0.008)	(0.016)*	(0.020)*	(0.006)	(0.007)
The inflation rate, GDP deflator (annual %)	0.003	0.003	-0.007	-0.008	-0.045	-0.044	-0.020	-0.014
	(0.005)	(0.004)	(0.009)	(0.004)**	(0.015)***	(0.012)***	(0.010)*	(0.006)**
Government debt, % of GDP	-0.003	-0.000	0.010	0.002	0.017	0.020	0.001	-0.004
	(0.004)	(0.001)	(0.006)	(0.002)	(0.015)	(0.006)***	(0.004)	(0.002)**
World Government Indicator								
Government effectiveness, -2.5 (weak) to 2.5 (strong) governance performance	1.583	3.570	0.025	-0.441	-0.038	-0.073	-0.008	0.159
	(0.899)*	(0.356)***	(0.960)	(0.224)**	(0.916)	(0.493)	(0.206)	(0.104)
Socio-economic variables								
Human Capital Index, from 0 to infinite potential	16.939	3.552	2.021	-4.174	9.637	4.530	5.846	3.104

	(3.708)***	(1.349)***	(2.728)	(0.517)***	(2.928)***	(1.140)***	(0.951)***	(0.369)***
The unemployment rate, annual, age 15-65, Percentage	-0.308	-0.191	-0.160	-0.047	-0.066	-0.105	0.044	0.035
	(0.135)**	(0.055)***	(0.080)*	(0.023)**	(0.076)	(0.034)***	(0.017)**	(0.009)***
Gini index, 0 (perfect equality) to 1 (perfect inequality)	-0.102	-0.025	-0.047	-0.016	-0.262	-0.182	0.019	-0.001
	(0.095)	(0.023)	(0.048)	(0.014)	(0.183)	(0.036)***	(0.043)	(0.014)
Population density, people per sq. Km	0.027	0.010	0.018	-0.002	-0.013	-0.009	0.003	0.000
	(0.018)	(0.004)**	(0.007)**	(0.003)	(0.005)**	(0.003)***	(0.003)	(0.001)
Constant	18.548	44.672	46.858	77.705	60.195	86.122	42.090	62.001
	(8.046)**	(2.538)***	(4.638)***	(2.113)***	(10.159)***	(4.492)***	(2.414)***	(1.645)***
Year fixed effects	NO	YES	NO	YES	NO	YES	NO	YES
N. Observations	511	511	573	573	528	528	584	584
log-likelihood	-884.7	-757.0	-755.8	-563.1	-869.2	-824.5	-283.6	-166.2

Notes:

Fixed effects panel data estimates. The regressand is a life expectancy at birth in year t—robust standard errors in parenthesis in each income group's first and third column.

*** p<0.01, ** p<0.05, * p<0.1. Annual data on 138 countries over the period 2000-2018. Specifications with year-fixed effects are jointly significant at a 1% level in all cases.

2.5. Conclusions and implications

Our results suggest that the volume of healthcare expenditures is essential for healthcare outputs, proxied by Life expectancy at birth. Thus, to continue improving the LEB of the population for all countries and all levels of income, it is necessary to invest in their Health care systems. However, according to our results, just increasing expenditures is not enough. Given the strong effect of macroeconomic stability, institutional quality, human capital level, unemployment, and income inequality on LEB, we would suggest that it is worthwhile for governments and other healthcare policymakers to look simultaneously at additional mechanisms and policies to improve LEB.

Then, our findings suggest that fulfilling targets such as a high LEB, improving health system efficiency, and dealing with increasing pressures on the health system coming from population ageing or unexpected illnesses, requires more than increasing the HCE volume. A more integral approach would be necessary, including factors such as education promotion, less unequal income distribution, economic stability, or the quality of institutions.

3. HEALTH CARE EXPENDITURES AND EFFICIENCY DISPARITIES AMONG HIGH-INCOME COUNTRIES

3.1. Introduction

Reaching efficiency in health care, currently, is a crucial objective of the health care systems throughout the world. Mainly owing to rising healthcare demand, the burden related to population ageing, and the threat of financial unsustainability due to historically high levels of public debt, the role of efficiency gains relevance in managing the health sector.

However, there are many more reasons to focus on new policies of healthcare systems development based on value and efficiency. Those are poor-quality healthcare services [30], preventable medical errors [28], weak management [54][103], unused assets as healthcare data [104], population illiteracy about health care [19] and lame financial and price policies[49].

The snowball of the push mentioned above factors results in that about one-fifth of Health care expenditure makes no or minimal contribution to good health outcomes [27]. That is why we believe that policies to improve the efficiency of health spending at the margin should be reviewed to keep the expenditure on health care under control and still improve health care outputs.

For instance, Health care expenditure (HCE) among high-income countries with similar high healthcare outputs (relative to the world average) varies from 4% in Turkey to almost 17% in the United States (USA) (2019) [26]. These data suggest the existence of room for improvements in allocation policies without damaging healthcare outputs.

Studies about the efficiency of HCE reallocation are less frequent due to the relative subjectivity of the issue and the lack of data or transparency [64]. This is why most related studies are done on the specific country case [105]. For instance, particular interest was devoted to examining the USA case due to the extremely high HCE and its lacklustre healthcare outputs [106] [107] [108]. The most relevant comparative analysis of the existing disparities of the high-income countries was done by Papanicolas [109] [52].

Macroeconomic investigations that analysed the issue of reallocation inefficiency also considered poor reallocation decision of policy-makers to be the main reason underlying HCE disparities across high-income countries [110] [56] [61] [111]. However, those studies were criticized due to significant differences in the study designs and methods, suggesting a lack of internal validity of the efficiency estimates [92].

In this study, we analyse whether the disparities above among the countries on health results are derived from divergent levels of health expenditure or depend on other factors which could be not directly related to health activities. We compare performance among 37 high-income countries, using cross-sectional data from 2000 to 2019, relying on key metrics of nine categories that underpin healthcare spending. By analysing HCE's cross-sectional drivers, we aim to discover some reasons that may explain the disparities in HCE across countries with similar income levels.

We try to find ways to improve health outputs other than rising health expenditure. We expect to contribute by analysing vias to improve health care efficiency in those countries that spend more and have the same results. Also, another goal of this paper is to provide high-income countries with some guidance about the most relevant factors that may boost healthcare efficiency.

The rest of this chapter is organized as follows. Section 2 describes the data and methodology used for the investigation. The results are presented in section 3. Section 4 discusses the implications of the main results, and finally, section 5 concludes.

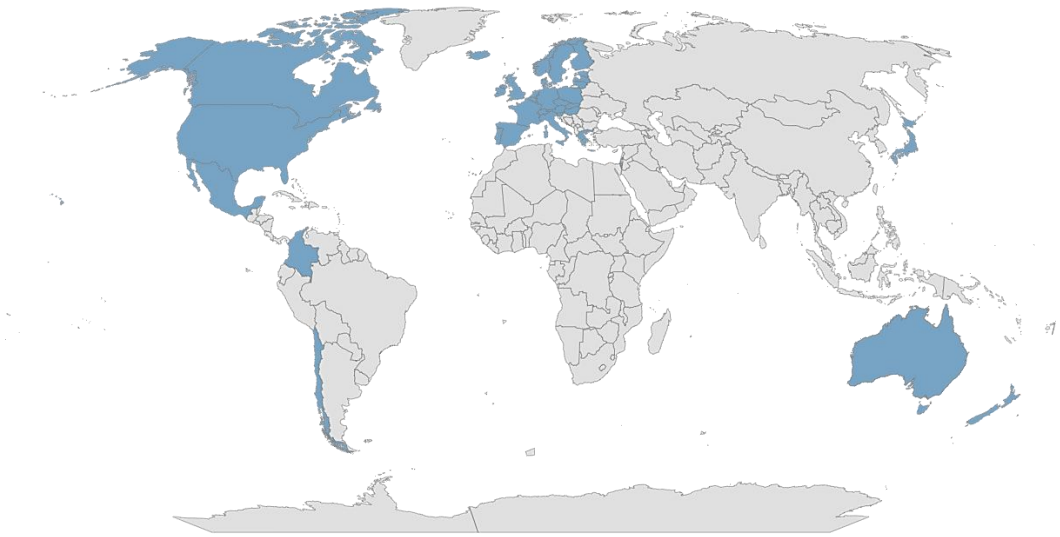
3.2. Data and Methods

3.2.1 Data

This paper uses yearly country-level data for 37 high-income countries from 2000 to 2019 to analyse the impact of macroeconomic variables and six healthcare indicators on healthcare efficiency. The goal is to investigate the main determinants of healthcare expenditure disparities among selected countries to provide guidance on improving healthcare efficiency in delivering high-quality and financially sustainable outcomes, which is deemed essential nowadays.

For this study, we selected those OECD countries that meet the condition to have their Gross Domestic Product (GDP) per capita (PPP, constant 2017 international USD) above 60% of the OECD GDP per capita median. Figure 3. 1 shows the countries included in the analysis (the list is available in APPENDIX I Table A. 5).

Figure 3. 1 World map with selected countries

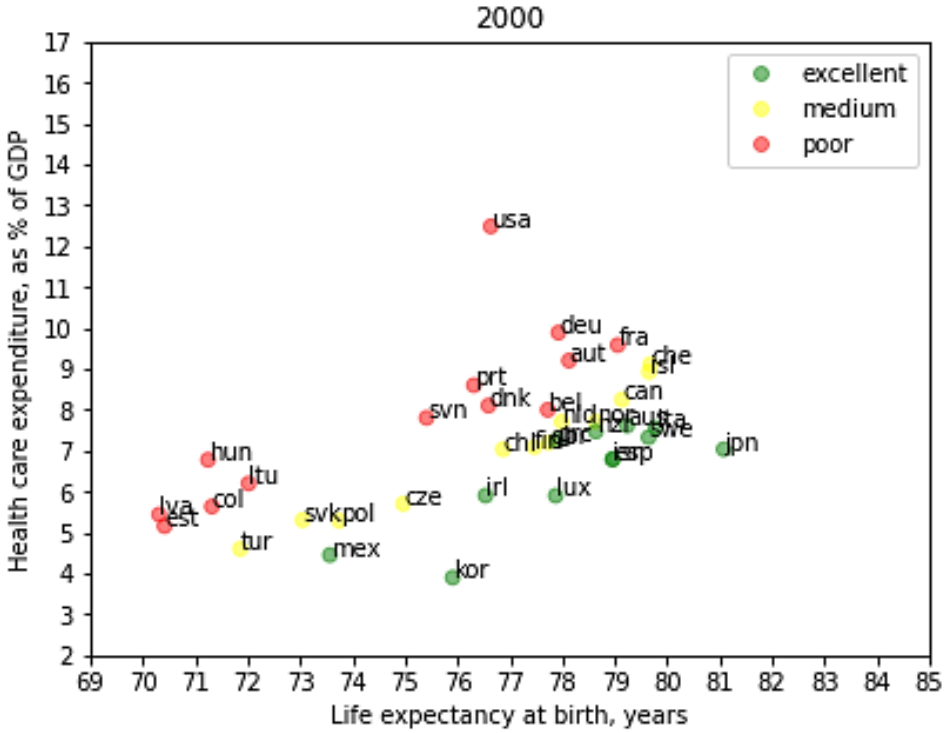


Source: Elaborated by the author

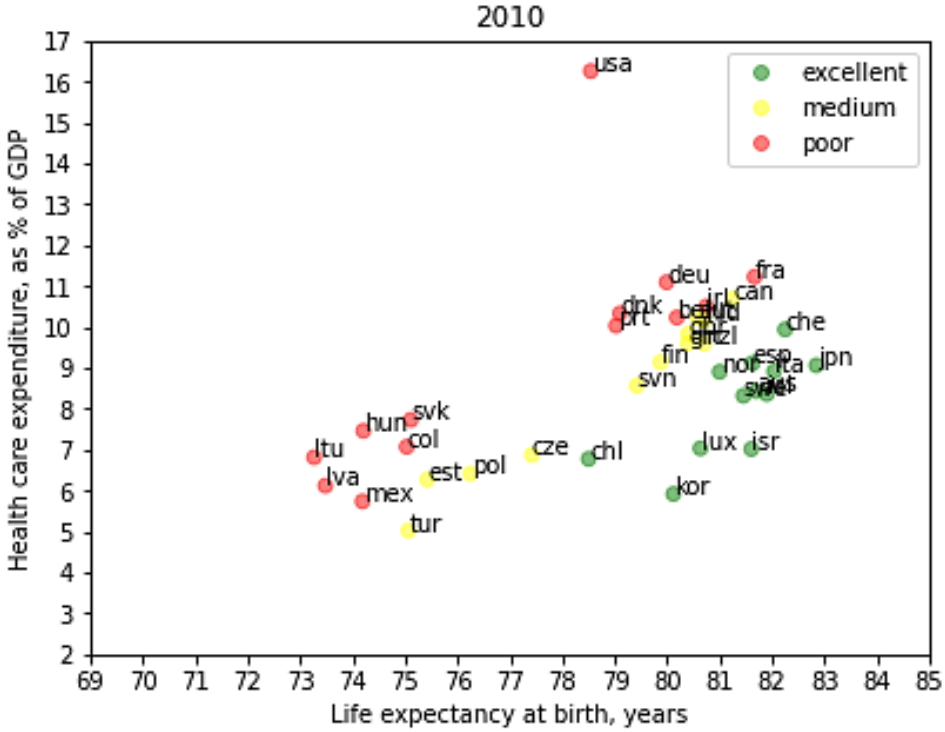
In this study, we define healthcare efficiency relying on two variables. These two variables are Life Expectancy at birth (LEB) (number of years) as an output of the health care system and Health care expenditure (HCE) as a percentage of GDP as an input. We classified the countries into three efficiency groups according to the terciles of the distribution of each of these variables for each year. Countries with low HCE (lowest tercile) and high Life expectancy (highest tercile) were defined as the *Excellent efficiency group*. Conversely, countries with relatively high HCE (highest tercile) and low LEB (lowest tercile) were grouped into the *Poor efficiency group*. The remaining cases are pooled together into a *Medium efficiency group*. Figure 3. 2 shows the countries' efficiency categories in 2000, 2010, and 2019.

Figure 3. 2 Country efficiency groups

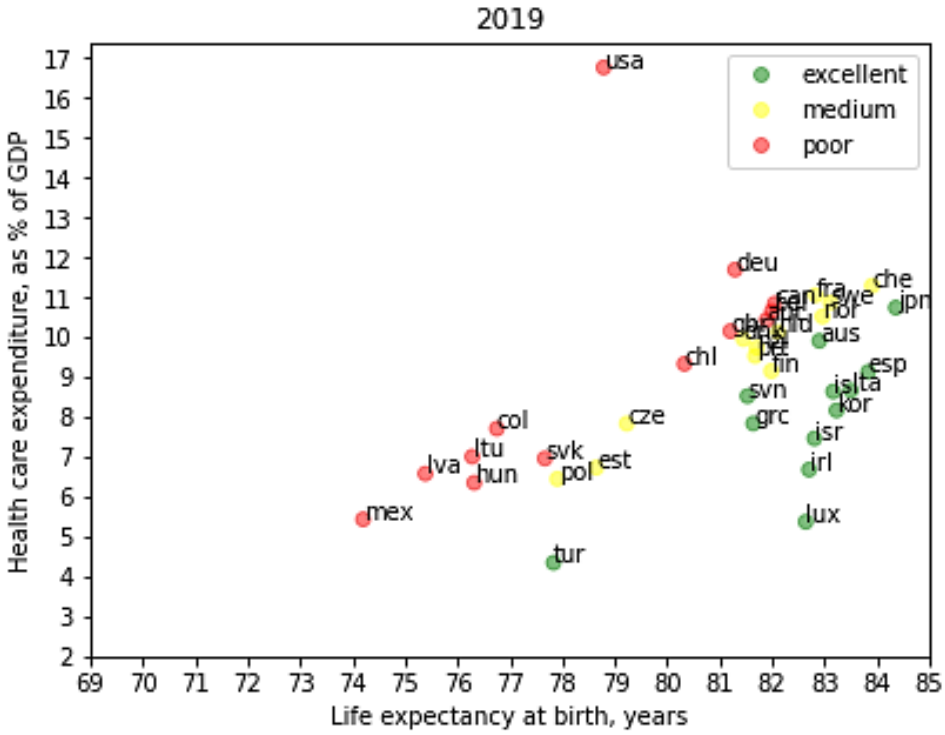
a) Countries' efficiency groups in 2000



b) Countries´ efficiency groups in 2010



c) Countries´ efficiency groups in 2019



Source: Elaborated by the author

In our database, the mean indicator of LEB is around 79 years. The country with the minimum years of life is Estonia (around 70 years in 2001), and Japan reached the maximum level of LEB in the selected period (more than 84 years in 2019). While Korea has the lowest indicator of HCE (less than 4% of GDP in 2000), and the USA almost reached 17% in 2016. Table 3. 1 presents the summary statistics of all the variables.

The explanatory variables are split into the following seven groups: (i) macroeconomic variables; (ii) demographic indicators; (iii) health care indicators as Health care expenditures by function; (iv) population health; (v) pharmaceutical; (vi) access, distribution and equity; and, (vii) innovation. Table 3. 2 provides variable definitions and data sources.

Table 3. 1 Summary statistics (2000-2019; 37 countries)

Sub-group	Variable	Mean	Standard Deviation	Min	Max	Missing, %
	Life expectancy at birth, total years	78.896	3.141	70.259	84.356	0%
	HCE, % Gross Domestic Product (GDP)	8.282	2.142	3.898	16.844	0%
Macroeconomic						
	Gini index, 0 (perfect equality) to 100 (perfect inequality)	33.468	6.657	23.2	58.7	0%
	Real GDP growth, annual growth, -constant 2010 USD	2.546	3.1	-14.839	24.37	0%
	Government Effectiveness, -2,5 to 2,5	1.191	.769	-2.085	2.354	0%
Demography						
	Population > 65 years, % of population	15.189	4.209	4.581	29.28	0%
Health care expenditure by function						
	Preventive care, Share of current expenditure on health	2.778	1.312	.022	6.818	0%
	Governance and administration, Share of current expenditure on health	3.45	2.444	.456	13.041	0%
Population health						
	Alcohol consumption, Litres per capita (15+)	9.195	2.82	1.2	14.8	0%
	Mediterranean diet, Index	.216	.412	0	1	0%
Pharmaceutical spending						
	Pharmaceutical spending, % of health spending	17.596	6.732	.722	40.239	0%
Access, distribution and equity						
	Out-of-pocket spending, % Current health expenditure	20.871	9.238	7.138	55.664	0%
Innovation						
	Research and development expenditure, % of GDP	1.786	1.019	.131	5.14	0%

Table 3. 2 Definition of variables and data sources

Sub-group	Variable	Abbreviation	Description	Source
	Life expectancy at birth	leb	total (years)	WDB
	HCE % gdp	hcegdp	% Gross Domestic Product (GDP)	WDB
Macroeconomic				
	Gini index	gini	0 (perfect equality) to 100 (perfect inequality)	WDB
	Real GDP growth	gdp	annual growth, constant 2015 USD	WDB
	Government Effectiveness	wgige	-2,5 to 2,5	WGI
Demography)				
	Population > 65 years	pop65	% of population	WDB
Health care expenditure by function				
	Preventive care	pchce	Share of current expenditure on health	OECD
	Governance and administration	gahce	Share of current expenditure on health	OECD
Population health				
	Alcohol consumption	ac	Litres per capita (15+)	OECD
	Mediterranean diet	mdiet	Index	OECD
Pharmaceutical spending				
	Pharmaceutical spending	pshce	% of health spending	OECD
Access, distribution and equity				
	Out-of-pocket spending	hceoopp	% Current health expenditure	WDB
Innovation				
	Research and development expenditure	rd	% of GDP	WDB

We include several potentially relevant economic, social, and institutional variables to account for the link between factors not directly related with the health sector and LEB. Those variables include real GDP growth and the Gini Index, a social income inequality indicator. It ranges from 0 to 100, meaning perfect equality and maximum inequality in income distribution, respectively. Finally, to account for the impact of institutional quality on health outputs, we use Government Effectiveness. It ranges from approximately -2.5 (weak) to 2.5 (strong) governance performance [98].

Among the demographic factors, we include the percentage of the population over 65 years old. In our database, Colombia has the youngest population (5% in 2000), and almost 30% (2019) of the Japanese are older than 65.

We split all healthcare indicators that determine HCE into several categories: Expenditures by function, Population health, Pharmaceutical spending, Access, distribution and equity, and Innovation.

The specific health variables we select for those categories are primarily determined by data availability. Hence, among all functions of HCE, we choose Preventive care and Governance and Administration areas of expenditure.

An Alcohol consumption indicator and a Mediterranean diet variable may proxy population health. We add this control variable as a dummy based on the Mediterranean adequacy index (MAI) calculated in the studies for the latest available period [112]. According to summary statistics, Turks consume around 1,5 litres of alcohol per capita on average (per year). In contrast, in Lithuania, the average amount of alcohol per capita reaches almost 15 litres (per year).

The group of Pharmaceutical spending includes the rate of Private out-of-pocket spending on pharmaceuticals as a percentage of total health spending. The lowest range of pharmaceutical spending in our data base belongs to Norway (less than 6% in 2000), in contrast with the Slovak Republic, which exceeds 40% of health spending (2003). Out-of-pocket healthcare spending represents access, distribution, and equity group as a percentage of total HCE. Around 7% of the French HCE is paid by the Out-of-pocket

scheme, while Mexico has the highest level of private spending and reaches 55% of the total.

We measure Innovation with Research and Development expenditure as a percentage of GDP. Colombia has the lowest level of R&D investment in healthcare (less than 1%), and Israel leads the statistics with more than 5% in 2019.

3.2.2 Methods

This section explores the likelihood and the drivers of three possible (and mutually exclusive) outcomes for our efficiency indicator: low expenditure, high LEB; low (high) expenditure, low (high) LEB; and high expenditure, low LEB.

This part of the analysis aims to identify factors associated with the likelihood of attaining each possible efficiency outcome. We estimate several specifications of an ordered logit model using annual data on 37 countries from 2000-2019.

We undertake a latent variable approach. In this context, Y* is the latent variable (i.e., a proxy for the proper performance) crossing progressively higher thresholds:

$$Y_i * = \beta X_i + \varepsilon_i \quad (2)$$

The three categories are corresponding to alternative health efficiency outcomes are defined by two thresholds (α_1, α_2), such that if $Y_i^* \leq \alpha_1$, the outcome is *low efficiency*; if $\alpha_1 < Y_i^* < \alpha_2$, the outcome is *intermediate efficiency*; finally, if $Y_i^* \geq \alpha_2$, the outcome is *high efficiency*. The *j*-category probability (*j=1: low efficiency, 2: intermediate efficiency, 3: high efficiency*) is defined as follows:

$$Pr(Y_i = j) = F(\alpha_{j-1} < Y_i^* \leq \alpha_j) = F(\alpha_j - \beta X_i) - F(\alpha_{j-1} - \beta X_i)\, Pr(Y_i = j) = F(\alpha_{j-1} < Y_i^* \leq \alpha_j) = F(\alpha_j - \beta X_i) - F(\alpha_{j-1} - \beta X_i) \quad (3)$$

where *F* is the logistically distributed function, and *X* is the vector of explanatory variables.

Table 3. 3 presents the correlation coefficients across variables and provides summary statistics of each variable for the different efficiency groups.

Table 3. 3 Bivariate correlations and descriptive statistics of the variables by efficiency

Variables	Abbreviation	Correlation	poor	medium	excellent
			mean (sd)	*Mean (sd)*	*mean (sd)*
Life expectancy at birth	leb		76,95	79,23	80,85
			(3.30)	(2.63)	(2.00)
HCE % gdp	hcegdp		8,86	8,36	7,57
			(2.75)	(1.74)	(1.44)
Macroeconomic					
Gini index	gini	-0.079	34,6	32,22	33,39
			(7.82)	(5.98)	(5.61)
Real GDP growth	gdp	0.054	2,19	1,94	2,59
			(3.47)	(3.39)	(3.36)
Government Effectiveness	wgige	0.003	1,12	1,34	1,12
			(0.63)	(0.61)	(1.00)
Demography					
Population > 65 years	pop65	-0.051	15,43	15,5	15,05
			(4.27)	(3.82)	(4.66)
Health care expenditure by function					
Preventive care	pchce	-0.068	2,69	3,31	2,45
			(1.08)	(1.61)	(1.11)
Governance and administration	gahce	-0.178	4,11	3,13	3,04
			(2.27)	(2.40)	(2.55)
Population health					
Alcohol consumption	ac	-0.254	10,01	9,1	8,32
			(2.85)	(2.85)	(2.84)
Mediterranean diet	mdiet	0.329	0,08	0,19	0,4
			(0.27)	(0.39)	(0.49)
Pharmaceutical spending					
Pharmaceutical spending	pshce	-0.140	18,90	17,02	16,46
			(7.24)	(7.17)	(5.15)
Access, distribution and equity					
Out-of-pocket spending	hceoopp	0.022	20,99	20,11	21,5
			(9.62)	(9.12)	(8.91)
Innovation					
Research and development expenditure	rd	0.230	1,53	1,74	2,15
			(0.94)	(0.88)	(1.15)

Some variables point towards apparent differences among the country groups. For instance, countries with *low healthcare efficiency* tend to have higher social inequality and spend more than other groups on Governance and administration of healthcare.

Their population has a less healthy lifestyle and spends more on pharmaceutical goods. In addition, the indicator of the R&D investment is lower.

In contrast, *high-efficiency countries* have more economic stability. Their population is younger, has healthier lifestyles than other efficiency groups, and spends less on pharmaceuticals. These countries tend to invest more in R&D and spend less on administration functions of healthcare.

We might distinguish higher social equality and institutional quality levels among the intermediate efficiency group characteristics. Their expenditure on prevention care is noticeably higher than in other countries. Unlike other groups, the quality of lifestyle of the population is moderate. Nevertheless, the out-of-pocket spending is the lowest.

Based on the previous observations, we expect a negative association of the Gini Index with healthcare efficiency for our socioeconomic variables. Real GDP growth is usually negatively related to health efficiency (less developed countries tend to grow more), and the opposite is true regarding Institutional Quality. Finally, a negative correlation between the ageing population and healthcare efficiency is anticipated.

Regarding HCE by function, following previous studies, we expect to observe a positive impact of preventive care investment and the opposite result with Governance and administration spending according to the studies [113]. We assume that a healthy population lifestyle improve the efficiency of healthcare systems. Pharmaceutical and out-of-pocket spending may have a negative effect. Finally, inversions in research and development may positively impact healthcare efficiency. Table 3. 4 presents a summary of all our hypotheses.

Table 3. 4 Hypothesis

Sub-group	Variable	Hypothesis
Macroeconomic		
	Gini index	-
	Real GDP growth	?
	Government Effectiveness	?
Demography		
	Population > 65 years	-
Health care expenditure by function		
	Preventive care	+
	Governance and administration	-
Population health		
	Alcohol consumption	-
	Mediterranean diet	+
Pharmaceutical spending		
	Pharmaceutical spending	-
Access, distribution and equity		
	Out-of-pocket spending	-
Innovation		
	Research and development expenditure	+

3.3. Results

3.3.1 Baseline results

Table 3. 5 displays baseline results from estimating equation (1), and several essential conclusions stand out. First, as expected, an ageing (aged) population is a crucial determinant of output results, with LEB strongly and negatively affected by the percentage of the population above 65 years old. Among socioeconomic factors, income inequality negatively affects healthcare efficiency; however, other indicators do not seem relevant to explaining different LEB within developed countries. Second, our study states the initial hypothesis that a low percentage of health expenditure devoted to administration and governance significantly contributes to a better health output. Third, according to our expectations, lifestyle shows a robust explanatory power when analysing LEB; the positive and significant effects of a Mediterranean diet and the negative and significant impact of alcohol consumption underpin this idea. Forth, we also meet the projection regarding the level of health R&D expenditure contribution to a higher LEB. Fifth, a relatively higher level of Pharmaceuticals spending arises as a negative factor in ensuring better health results.

Table 3. 5 Ordered logistic regression results (2000-2019; 37 countries)

Variables	Coef.	St.Err.	p-value	[95% Conf	Interval]	Sig
Macroeconomic						
Gini index, 0 (perfect equality) to 100 (perfect inequality)	-0.092	0.018	0	-0.127	-0.058	***
Real GDP growth, constant 2010 USD	0.029	0.026	0.264	-0.022	0.079	
Government Effectiveness, -2,5 to 2,5	-0.151	0.139	0.279	-0.423	0.122	
Demography						
Population > 65 years, % of population	-0.145	0.027	0	-0.198	-0.091	***
Health care expenditure by function						
Preventive care, Share of current expenditure on health	-0.058	0.06	0.33	-0.175	0.059	
Governance and administration, Share of current expenditure on health	-0.222	0.041	0	-0.303	-0.141	***
Population health						
Alcohol consumption, Litres per capita (15+)	-0.102	0.039	0.009	-0.178	-0.025	***
Mediterranean diet, Index	2.162	0.226	0	1.719	2.605	***
Pharmaceutical spending						
Pharmaceutical spending, % of health spending	-0.079	0.017	0	-0.112	-0.045	***
Access, distribution and equity						
Out-of-pocket spending, % Current health expenditure	0.041	0.011	0	0.019	0.063	***
Innovation						
Research and development expenditure, % of GDP	0.481	0.098	0	0.288	0.673	***
Mean dependent var	1.973	SD dependent var				0.822
Pseudo r-squared	0.165	Number of obs				740.000
Chi-square	268.907	Prob > chi2				0.000
Akaike crit. (AIC)	1.381.968	Bayesian crit. (BIC)				1.441.854

**** p<.01, ** p<.05, * p<.1*

Finally, unlike our expectations, the out-of-pocket health expenditure seems significant to ensure a better health output within rich countries, and it shows a positive sign in our regression.

3.3.2 Further results

As robustness checks, we have re-estimated our baseline model using alternative variables for each group of indicators. In addition, we tried to include different groups of healthcare indicators such as healthcare resources, their utilization and e-health. However, the limitation of the data did not allow us to proceed. All the variables are presented in APPENDIX I Table A. 6 Variables analysed in the robustness checks

Nevertheless, in the case of institutional quality, we analysed all the variables that compound World Government Indicators in addition to Government Effectiveness. These are Voice and Accountability, Political Stability, No Violence, Regulatory Quality, Rule of Law, and Control of Corruption. The baseline results remain qualitatively unaltered.

As the data on Health care resources and utilization variables are incomplete, we use the equalization method to calculate compound indexes for both categories. The Health care resources Index comprises four normalized variables: Practising workforce, Workforce remuneration, Equipment, and Hospital beds. Moreover, the Health care utilization Index includes data about Mental behavioural, Examinations by Magnetic resonance imaging units, Surgical procedure of knee replacement, and Length of stay per capita exposure by Acute myocardial infarction. Only one index linked to the availability of health resources is significant and positively impacts healthcare efficiency.

3.4. Discussion

This study investigates the disparities between developed countries with similarly relatively high healthcare outcomes (such as Life expectancy at birth) but significant differences among their healthcare expenditures. We aimed to analyse the factors that lead to such relevant differences in the efficiency of the system in order to find potential paths to improve health outputs other than a rising health expenditure. To that end, we used cross-country data on 37 high-income countries from 2000-2019

As expected, countries with a high population above 65 tend to have more financial burdens on their healthcare systems. Another significant result shows that the population's healthy lifestyles help efficient healthcare systems. Also, investment in healthcare innovations strongly impacts healthcare efficiency.

Socioeconomic factors, such as income distribution, seem relevant in explaining different efficiency within developed countries. We also observed a negative impact of Administration and governance expenditure on the outcomes of the system. Regarding the fact that Institutional quality indicators do not show significant results with health care outcomes, we believe that additional investigation on the causality of these two factors is needed.

The most unexpected result in our study is the negative relationship that we find between the level of health expenditure on prevention care and LEB. Additional studies are needed in this area.

3.5. Conclusions and implications

Our results suggest that the ageing population is a crucial determinant of healthcare efficiency. On the other hand, a healthy lifestyle (in our study, avoid alcohol and follow a Mediterranean diet) and social equality prevent health care systems' financial burden and lead to longer Life expectancy. As expected, countries investing in healthcare research and development tend to have more efficient health systems. In contrast, higher healthcare expenditure on Governance and Administration among high-income countries showed a negative fingerprint on the systems efficiency and pharmaceutical spending.

Thus, more paths exist to fulfil high healthcare outcomes in developed countries other than rising health expenditure. Those are socioeconomic equality, lifestyle and healthcare innovations.

4. STRATEGY OF HEALTH CARE SYSTEM EFFICIENCY IMPLEMENTATION: CONCEPTUAL FRAMEWORK

"Culture eats strategy for breakfast."

Peter Drucker

4.1. Introduction

On the one hand, socio-economic threats to health care are related to rising demand, the burden related to population ageing and financial unsustainability. On the other, the extant literature points out several challenges arising from current systems´ imperfections, such as poor-quality healthcare services [30], preventable medical errors [28], unused assets as health care data [104], population illiteracy about health care [19] a lame financial and price policies [49], and non-effective management [54][103].

All these factors draw the attention of the healthcare research ecosystem to investigate the concept of healthcare efficiency. A variety of theoretical and practical approaches were designed. However, they may make it challenging to apply for healthcare providers due to the particularity and complexity of the system.

This study aims to provide a clear view of healthcare efficiency as a strategy. We started by clarifying fundamental concepts of healthcare efficiency, defining the managerial role in efficient implementation and, finally, introducing the conceptual model of healthcare implementation as a strategy.

4.1.1 Concept of health care efficiency

In multiple studies, the concept of healthcare efficiency is unclear and tends to be confused with effectiveness [114], [115]. Effectiveness is about doing the right things or being adequate to accomplish a purpose, while efficiency is a somewhat more precise concept. In most cases, researchers consider efficiency related to (relatively) low healthcare expenditures and (relatively) high healthcare outcomes, such as life expectancy at birth or mortality indicators. [116], [115] [117] [105]. It is related to delivering the best outcome at the minimum cost.

More specifically, we should distinguish at least four levels of efficiency: Production, Allocation, Technical, and Scale. Production efficiency addresses the issue of using optimal combinations of resources to maximize health output. Allocation efficiency ensures the proper allocation of resources across programs to maximise the overall good. It is more about achieving the right mixture of healthcare programs to maximise society's health [118]. If the output is produced with the minimum inputs, it is called technical efficiency. Scale efficiency occurs when an organization operates at the optimal production size, which is the point of long-term equilibrium [119].

Other similar but not identical concepts exist as healthcare quality and value-based healthcare. Healthcare quality can be improvements reached in documentation, sanitary commission, innovation, sterilization, technology, pharmaceuticals, health financing, the role of industrial and mass production [1] or education [120]. Value-based health care is considered a synthesis of what matters to patients while combining the interests of all actors in the system [121], and it is mainly seen as a health care outcome [64] [122]. Even so, none of the above links the results with the costs.

Some methods commonly used to calculate cost efficiency include Quality Adjusted Life Years [123] [124], Disability-Adjusted Life Years, Health Technology Assessment, or Cost-Effectiveness Analysis.

In this paper, we consider efficiency as a relationship between the results and the costs when a certain level of healthcare performance is attained in the best possible manner, which involves the minimum waste of time and effort.

4.1.2 Managerial role in health care efficiency

Understanding the strategic management concept regarding the figure who provides the efficiency is essential. It has been employed within healthcare organizations only in the past 30 to 35 years when healthcare has become a complex business using many of the same processes as the most sophisticated business corporations. Indeed, in the late 1980s and 1990s, many healthcare organizations had much to learn from strategically managed businesses [126].

Nowadays, strategic management of healthcare organizations is ultimately a decision-making process. Managers operating in different contexts and institutions at all system levels make conscious decisions. About the direction that their organization will head, the goals they will pursue, the strategies they will implement, how these strategies will be implemented, how resources will be allocated, and how rewards will be divided. Excellent strategic decisions have a creative and rational process component that moves an organization to innovate [127].

Thus, healthcare competent management is considered one of the most promising tools and critical figures for healthcare system efficiency implementation.

According to the literature, an extensive list of managerial problems leads to negative consequences or inefficiencies resulting in health care system outputs and outcomes. Among the most frequent, we have the following: failures of care coordination, administrative complexity [60], fraud and abuse [59], overuse of resources [56] and weak education of human resources [57] [128] [129][25]. All these imperfections lead to higher costs, personal and patient dissatisfaction, and life losses [58].

A survey[3] of Spanish health care managers concerning their organizations' efficiency confirms the statements above. All the participants agreed about having inefficiencies in their organizations, especially in administrative areas, due to the lack of agility in the decision-making process, weak monitoring of the expenditures, outputs, and unoptimized resources.

Increasing healthcare demands [26] will inevitably provoke spillover effects on healthcare waste generation that must be proactively managed. Therefore, some managerial interventions are required.

Addressing managerial and sustainability issues requires a vision oriented towards the entire population and greater attention to allocative efficiency and cost control [62]. In addition, recent research suggests that hospital administrators and healthcare executives should be proactive in human resource planning, recruitment, and designing training programs in healthcare waste management. By doing so, effective results can be achieved, and consequently, human health and the environment can be sustained over time [63].

[3] Survey on the Spanish health care efficiency realized by one of the authors in 2022.

The rise in healthcare costs brought about by socio-economic factors and systems´ imperfections urges us to shift the focus to efficiency analysis as cost information underpins decisions on resource allocation and effectiveness at the system and organizational levels for providers, purchasers, and regulators globally [64].

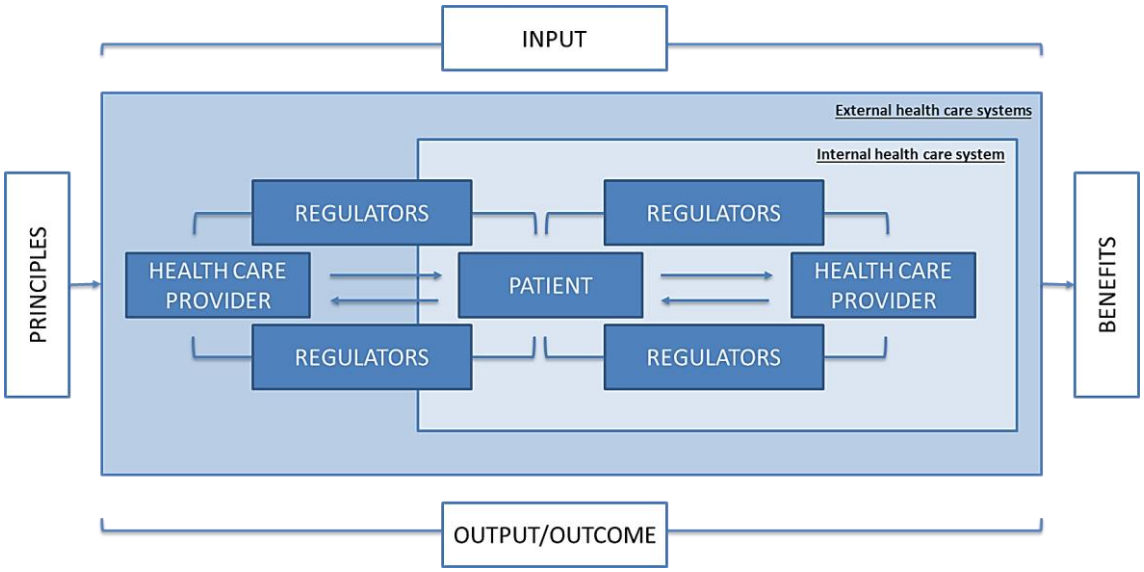
Thus, we argue that developing a conceptual framework for a strategy for healthcare efficiency implementation will provide a tool for administrators and help them manage the upcoming needs of the healthcare sector. Accordingly, we apply this framework to a real case. More specifically, we apply it to the surgical area of a medium-sized Spanish hospital.

The rest of the paper is organized as follows. In the next section, we develop the conceptual model inspired by the Project Management Institute's (PMI) existing standard of Program Management Professionals (PgMP) [130]. We link this conceptual model with the field of efficiency in health management. Section 3 presents the specific case study. Then, the last section offers the final reflections on this actual case study, pointing out our proposal for improvement.

4.2. Developing a conceptual framework

The healthcare system is a complex industry (Figure 4. 1) that includes three levels: patients, healthcare providers, and regulators. The system's engines are several objectives that vary among the levels. For instance, the patient expects the system to give her a better and longer life, a solution to her problems, the anticipation of those problems, social and financial risk protection, improved quality, and adaptation to the lifestyle and cycle (globalization and ageing). Healthcare providers want to save lives, improve health and financial sustainability, and professional training. Regulators aim to improve health, quality, safety, efficiency, social and financial risk protection, access coverage, health equity, financial risk protection, and responsiveness. However, a large consensus about the meaning of value is still missing. Patients, physicians, policymakers, and other healthcare professionals have different ideas on which value component may play a prominent role [131].

Figure 4. 1 Health care system theoretical model



Source: Elaborated by the author

In addition, the health care system is driven by a range of principles or basic ideas and rules that make the mechanism work in a clear direction. Healthcare principles are not standardised, and there are few works about common healthcare system principles. Some of the researchers suggest the following principles to follow in order to get integrative and successful healthcare systems: comprehensive services across the continuum of care, patient focus, geographic coverage and rostering, standardized care delivery through interprofessional teams, standardized performance management, information systems, organizational culture and leadership, physician integration physicians, governance structure and financial management.

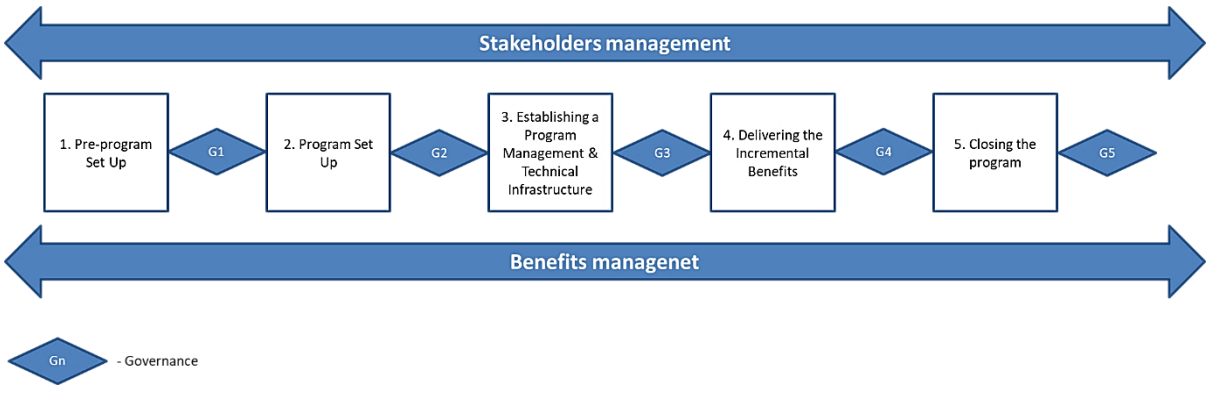
Indeed, there might be some common objectives and principles for healthcare systems and their levels; however, we cannot ignore the local context that leads to specific and unlike needs since a concrete healthcare unit depends on particular conditions and is led by individual motives.

The intricacy of the healthcare system complicates the standardized and unified approach to efficiency management. The PMI´s Standard for Program Management (PgMP) is an integrated and coherent methodology that would encompass the complexity of the healthcare system without harming local autonomy.

The PMI defines a *Program* as a group of related projects managed in a coordinated way to obtain benefits that cannot be managed individually. *Program* management is a program's centralized, coordinated management to achieve its strategic benefits and objectives. Managing multiple projects using a *Program* allows for optimized or integrated cost, schedules, effort, integrated or dependent deliverables across the *Program*, delivery of incremental benefits, and optimization of staffing in the context of the overall program's needs.

As Figure 4. 2 shows, an effective *Program* encompasses many areas, although three broad management themes are critical to a program's success: *Benefits* management, *Program Stakeholder* management, and *Program Governance* policies. To be successful, *Benefits* management must begin when the *Program* is initiated, in the *Pre-Program Set Up* and *Program Set Up* life cycle phases. Stakeholders should clearly define and agree on the factors contributing to benefits and a supporting structure and processes to help plan, manage, measure, track, and realize the benefits. The phase *Gate Reviews* are generally focused on strategic alignment, investment appraisal, monitoring and controlling opportunities and threats, benefit assessment, and program outcomes.

Figure 4. 2 Program Life Cycle



Source: Elaborated by the author

Programs and *Program* management exist within a strategic context and operate as strategy implementation vehicles. It moves through discrete, often overlapping phases to ensure effective Program control. These phases are *Pre-program Set Up, Program Set Up, Establishing a Program Management & Technical Infrastructure, Delivering Incremental Benefits, and Closing the Program*.

We believe that innovative strategic management tools for healthcare managers should be designed to help to find inefficiencies and implement and maintain the changes required to reach efficiency in healthcare. Despite the complexity of healthcare systems, the new solutions should be coherent with the global healthcare objectives and principles without ignoring the local context.

In the next section, we try to design a conceptual model of a consistent guide for healthcare managers that will help to identify the inefficiencies and design and implement the solutions needed to reach efficiency in a healthcare organization.

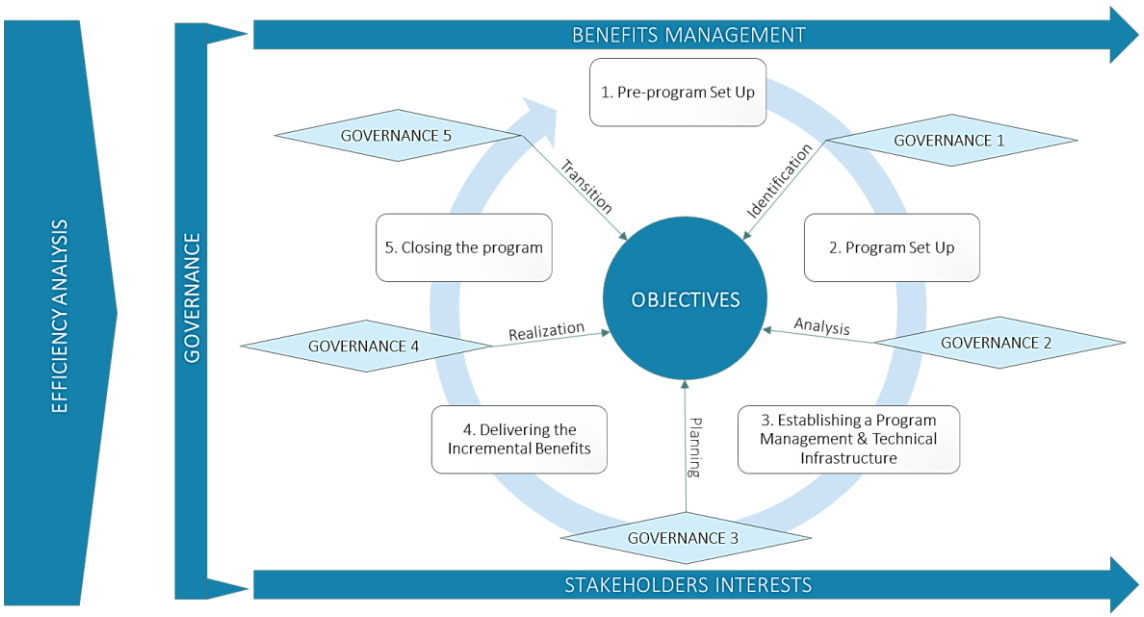
4.2.1 Conceptual framework of the strategy of health care efficiency implementation

Healthcare managers, under the pressure of increasing demand and limited resources, are forced to find new strategic solutions based on efficiency. In this study, we develop a conceptual framework for implementing health care system efficiency that can help administration manage practical solutions with the optimal inputs and maximum outputs despite the health care system's complexity.

The conceptual framework (Figure 4. 3) mainly comprises the Program *Preparation* and *Implementation*. The *Preparation* includes the following steps: *Efficiency analysis*, *Objectives definition*, *Benefits management,* and *Stakeholders' interests*. Then, the *Implementation* process starts and consists of the five stages of the Program Life Cycle: *Pre-program Set Up, Program Set Up, Establish Program Management & Technical Infrastructure, Deliver Incremental Benefit, Close the Program*. The Governance team should monitor all the stages of the Implementation of efficiency.

The framework defines stages of the efficiency *Programs* implementation and provides a dynamic, rather than static, approach [133] to the implementation process. It also allows the manager to be autonomous with the instruments used at all stages. For instance, what objectives and key results (OKRs) might be defined and what key performance indicators (KPIs) should be measured [134] [62] [135] [25], or what methods should be used to define the expected benefits, which can be health-technology assessment, cost-efficiency analysis, etc [115]. Regarding the principles, the board of managers can also define those that are the most relevant for each *Program* [55] [136] [137].

Figure 4. 3 Strategy of health care system efficiency implementation conceptual framework



Source: Elaborated by the author

It is worth noting that the natural objective of improving management requires a thoughtful assessment of performance, which calls for adequate data, including accurate indicators to measure key performance gains, practical management tools, and training in healthcare management. When used appropriately, efficiency indicators may be essential tools to help decision-makers determine whether resources are allocated optimally and pinpoint which parts of the health system are not performing as well as they should.

We provide an actual case study of efficiency Program management to demonstrate the truthfulness and potential application of the proposed conceptual framework to healthcare management.

4.3. Case study: a medium-sized Spanish hospital

To test the viability of the conceptual framework of the strategy of healthcare efficiency implementation, we collaborated with a Spanish hospital, particularly in the case of the surgical department.

The hospital in our study is classified as a general hospital with functional dependence on health services and institutes of one of the seventeen autonomous communities in Spain. It has 266 beds (on average Spanish hospital has 191) [138], 35 specialities, three clinical areas,

six functional unities, three areas of care management, and three special oncological programs. The hospital provides medical services for a population of about 185,000 persons.

To find potential improvements, the hospital's quality management department decided to collaborate with the investigation by applying the conceptual framework to the surgery department, which consists of 13 operation rooms and provides more than 10,000 interventions annually.

4.3.1 Program preparation

During our research period, we conducted several interviews with managerial personnel. In addition, a previous study about the inefficiencies elaborated by a private company was explored. Also, it was analyzed a database with relevant data about the functionality of the department. It also designed a mind map with the functional organigram of the department.

Our efficiency analysis based on four years of data (2018-2021) allowed us to evaluate variables and tasks (Table 4. 1) that we group into four categories of potential outcomes:

1. Optimization of the use of the department´s resources, such as the operating rooms, tools, and human resources
2. Improvement of the surgery programming process
3. Patients´ satisfaction
4. Patient security

Table 4. 1 List of variables by category of potential outcomes

Categories	Variables
1	**Department´s resources use**
1.1	The performance of operating rooms
1.2	Replacement time in operating rooms
1.3	Entries on time
1.4	Intervention time
1.5	Intervention number
1.6	Unit of Surgery Without Admission (UCSI) Auxiliary USCI working time
1.7	Unit of Surgery Without Admission (UCSI) human resources satisfaction
1.8	Outpatient Surgery Unit (UCSI) Occupancy
1.9	Surgery Unit Without Admission (UCSI) Occupancy
1.10	Post Anaesthetic Recovery Unit (PACU) Occupancy
2	**Surgery programming process**
2.1	Human resources Compliance
2.2	Incidents
3	**Patient satisfaction**

3.1	The average number of patients per surgical session
3.2	Suspended interventions by type
3.3	Surgical prolongation
3.4	Absence of preoperative preparation
3.5	Patient waiting time of operation day
3.6	Waiting list
3.7	Patient waiting time from the day of operation till the procedure
3.8	Incidents
3.9	Patient tracking system
3.10	Patient satisfaction
4	**Patient security**
4.1	Postoperative readmission within 30 days
4.2	Postoperative infection withing 30 days

To decide whether the observed areas are related to the principles of the PMI and PgM, it is essential to evaluate their quantitative and qualitative impact on the organization. Table 4. 2 presents the economic estimation results of the areas mentioned above of potential improvements based on the related available evidence studies.

Table 4. 2 Quantitative evaluation of the potential impact of the efficiency implementation

ID	Areas of potential improvements	Quantitative evaluation
1	Optimization of the department´s resources use, such as the operating rooms, tools, and human resources (for 1% of increased performance)	180 000€
2	Improvement of the surgery programming process	20 000€
3	Patients´ satisfaction	100 000€
4	Patient security (every 1% of avoidable readmissions)	65 000€
Total		**365 000 €**

The data of our practical case led us to estimate that the potential improvements in a Surgery department may get to a minimum of about three thousand euros in quantitative terms. However, it is worth noting that these results are hypothetical and may vary depending on the organization. Also, higher performance of operating rooms implies increased use of the resources necessary to provide the service. Among qualitative outcomes, we may project improvements in health indicators, quality of life, and satisfaction for the patients and the hospital's human resources.

The program's next step consists of defining the *Objectives* of the efficiency establishment process. This phase requires the definition of reasonable targets for the key results indicators

(output and outcome), which should be hit after the corrections and improvements. For instance, if our analysis concludes that there is room for improvement in the operational room utilization, the objective of the efficiency *Program* may be defined as optimizing the use of the operating rooms where the percentage of the performance of operating rooms may figure as a critical result indicator to measure the goal achievement. For instance, if the performance of an operating room is under the recommended level [139], the critical result may be defined as reaching a performance target of the operating rooms of 85%.

The *Benefits management* assesses the value and organizational impact of the *Program*, identifies the interdependencies of benefits being delivered among various projects within the *Program*, ensures that targeted benefits are specific, measurable, actual, realistic, and time-based, and analyses the potential impact of planned *Program* changes on benefits outcome and assigns responsibilities and accountability for the actual benefits required from the *Program*. This stage requires specifying the benefits expected at the end of the program for each objective. For example, based on real-world data evidence [140], the implementation of a specific technological solution that provides a machine learning surgery programming process may reach to solve standard compliances and incidents by reducing manual work of the hospital human resources, which improves the satisfaction and improve patients' satisfaction by decreasing waiting time.

The *Stakeholders*' interest phase is needed to describe the individuals and organizations whose interests may be affected by the *Program* outcomes, either positively or negatively. In this context, *Program* plans should clearly show an understanding of and integration with generally accepted organisational change management methods.

Summing up, during the first part of the *Program*, an efficiency analysis of the surgical department was made, and the *Objectives*, key results, or *Benefits* in terms of outputs and outcomes, and *Stakeholders* of efficiency improvement were defined.

4.3.2 Program implementation

As a result of the previous phases of the *Program*, a clear list of efficiency improvements was defined, substantiated with the *Benefits* and *Objectives* expected and *Stakeholders* of the *Program*. The next step is the *Implementation* process which consists of the five stages

previously defined: *Pre-program Set Up, Program Set Up, Establish Program Management & Technical Infrastructure, Deliver Incremental Benefit, Close the Program*.

The Governance team should monitor all the stages of the implementation of the efficiency-enhancing strategy. There must be a board that will assume the functions, such as initiation of the *Program*, approval of *Program* plans and authorization of deviations from the plans, review of the *Program's* progress, benefits delivery, and costs, guidance on issues that the *Program* manager has been unable to resolve, assurance that resources are available for the *Program*, collection of input for strategic progress reporting, the establishment of frameworks and limits for making decisions about investments in the program, and compliance with corporate and legal policies, procedures, standards, and requirements.

At the stage of *Pre-program Set Up*, the Program manager must have a written document called a Business case which clarifies the following points:

- Context of the initial idea/suggestion/proposal
- Business case: Objectives and expected key results
- Project Product Description
- Implementation planning
- Necessary resources: Financial, HR, Time, etc.
- Study and forecast of the main risks

Program Set Up. After the first meeting of the Management Committee and its feedback on the first version of the Business case, the following points/ideas are identified:

- The list of tasks approved by the high direction
- A schedule is established over time
- The OKRs, and KPIs to be monitored

After approval by the *Governance* team analysis of the previous step, it comes to *Establishing a Program Management & Technical Infrastructure* process. Where the *Program* team defines the technical needs, resources, training, etc., for the *Implementation* of the Projects and assigned tasks, and the next Government meeting should plan the implementation work of the *Benefits* delivery.

The stage of *Incremental Benefits Delivery* is based on the execution of the Projects and tasks distributed among the *Program* team carried out under the *Delegation, Monitoring and*

Control of the Program Manager. The results of the *Program* realization might be constantly shared with the *Governance* team.

The stage of *Closing* the *Program* is essential to make the *Program* successful as it consists of auditing whether the indicators of the *Objectives* and established *Benefits* were reached. In addition, all the processes from the beginning must be analyzed, and the lessons must be discussed, recorded, and learned.

4.3.3 Potential efficiency gains

Applying the model to the actual case led us to estimate that the potential quantitative improvements within a surgery department may reach at least 360k euros in terms of annual economic savings by 1% of improvement. During the first steps of the *Implementation* process, a detailed investigation of the solutions and the expected values to obtain the changes were made. We describe the potential solutions that may contribute to all the potential improvements and a detailed estimation of the potential efficiency gains in quantitative and qualitative terms by the area.

One of the leading solutions analyzed to optimize the department´s resources was a technological tool that helps with the surgery programming process based on machine learning and patient tracking technology since manual surgery parts programming leads to a continuous breach of the surgery program in the system. Every change needs a manual intervention into the information system, which also produces delays and breakdowns in the surgery timetable. Most of the time, this is why the surgery staff, operating rooms, and tools are downtime. In addition, unforeseen programming failures produce long waiting times before and during the day of the operation. Additionally, an unoptimized use of the resources generates a decrease in the number of interventions by session.

The technological tool may help to minimize manual work. Additionally, it relies on the historical data of the operations, reviews the processes' times, and provides an optimal programming and control instrument. In quantitative terms, we estimate that the Return on investment on our proposal could reach more than 20k euros (22%) (see APPENDIX II) during the first year by the first 1% of improvement in the performance of the surgery department. Additional improvements, as the main cost is fixed, may generate much bigger net results as

the number of interventions may increase by about 7%, thus reducing the cost of the intervention by about 6% (141€ per intervention). It should be noted that these results do not include the burden of increased costs of additional resources needed to provide more services due to surgical production optimization.

Among the qualitative results obtained from the adoption of the proposed solution, there stand the work process fluency of the surgery department units, reduction of the patients waiting time during the day of the operation, and, as a consequence of the increasing operations during the session, improvement of the waiting list.

The analyzed tool also includes patient tracking technology. It will help a department manager to monitor the performance indicators of each stage of the patient in the surgery flow. Moreover, patients´ relatives can be informed about their relatives. The mentioned functionality can contribute to the data collection for managerial and quality improvement and better communication with the patient's relatives.

The tool may partially improve the third area of potential improvements or patient satisfaction by reducing waiting times and improving communication by tracking. However, additional effort is needed from the hospital to work the high suspensions. A detailed analysis indicates that around 44% of all suspensions are due to the patient´s absence on the day and hour of the operation. Another 18% derives from contradictions not caused by health conditions. Among the potential solutions, one possibility could be an improved system of notifications to the patients before the surgery. A collaboration of the hospital with the local authorities may help to find social workers to accompany patients with those needs to avoid suspension of the surgery.

Surgical site infections (SSI) are a common challenge in healthcare systems. Tight control of the data related to the statement is needed to improve the rate of incidents. It is essential the collection of specific data and constantly investigate it. Also, several training programs are available at national[4] and international[5],[6] levels.

[4] https://infeccionquirurgicazero.es/es/
[5]https://www.ecdc.europa.eu/en/publications-data/directory-online-resources-prevention-and-control-antimicrobial-resistance-amr
[6] https://openwho.org/courses/IPC-SSI-EN

To conclude, adopting a surgery programming technological tool, changes in the communication systems with the patients, and preventable and preventive measures for SSI may lead to significant quantitative and qualitative gains in the surgery department and hospital efficiency, human resources, and patient satisfaction.

4.4. Conclusions and implications

Healthcare systems are under pressure from increasing demand, patients' high-quality expectations and an increasing economic challenge to offer better results with limited resources. As a result, healthcare experts and managers are looking for innovative methods that could help them change the system and reach a higher efficiency of its functioning or, in other words, to perform in the best possible manner with the least waste of time and effort.

In this study, we suggest a conceptual framework for a strategy of health care efficiency implementation that may serve as a tool for healthcare managers and can help them to manage upcoming needs of the healthcare sector. We derived the structure for such a framework from the Project Management Institute (PMI) existing Program Management Professional (PgMP) standard.

The conceptual model of efficiency implementation consists of the *Preparation* and *Implementation* stages. The *Preparation* part includes a deep analysis of existing inefficiencies, a definition of the *Objectives* to reach, the *Benefits* expected, and the *Stakeholders* involved. The *Implementation* process consists of five steps*: Pre-program Set Up, Program Set Up, Establish Program Management & Technical Infrastructure, Deliver Incremental Benefits,* and *Closing the Program*. The Governance team controls each of them.

A transversal and proactive approach to the conceptual framework may help managers to design a consistent Program of efficiency implementation at the micro or macro level. It may also reduce some frequent managerial problems.

Applying the conceptual framework in the surgery department case of one of the Spanish hospitals demonstrates potential positive results. Four categories of outcomes were observed, which summed up more than three hundred thousand euros of potential gains annually by 1% of improvement.

5. CONCLUSIONS AND IMPLICATIONS

"Entre el 15% y el 20% de las cosas que se hacen en la sanidad pública no añaden valor clínico y son un desperdicio"[7]

Rafael Bengoa

5.1. Study objectives revision

During the last decades, healthcare has shown impressive results worldwide by gaining more than twenty life expectancy years at birth on average.

Before COVID-19, the driving forces of healthcare were the Sustainable Health Goals 2030. Their main idea consists of the provision of universal coverage of health care in all income countries groups. The pandemic, followed by Russia's war of aggression against Ukraine, led the world to uncertain economic and social outlooks. All these, among other challenges, force the healthcare system to adopt to the new reality. The one that demands resilience, sustainability and efficiency.

Currently, inefficient healthcare resource utilisation raises severe concerns for multiple reasons. Firstly, patients may not receive the best possible care within the resource limits of the health system, resulting in a denial of health benefits even after receiving treatment. Secondly, excessive resource consumption for ineffective treatment can prevent other patients from receiving treatment that could have benefited them if resources had been utilized effectively. Thirdly, inefficient use of resources in the healthcare sector may result in losing investment opportunities in other economic sectors such as education and nutrition. Lastly, inefficient utilization of resources may reduce society's willingness to fund healthcare services, causing harm to social solidarity, healthcare system performance, and social welfare [141].

[7] *https://www.elmundo.es/ciencia-y-salud/salud/2023/04/14/64381dc921efa0d81a8b457b.html*

Apart from its instrumental value, addressing inefficiency also has significant accountability value. It reassures payers that their money is being utilized efficiently and that patients, caregivers, and the general public their health system claims are being treated fairly and consistently.

Thereby, demographic change, rising chronic disease and multimorbidity, along with fiscal pressures and a wide range of determined inefficiencies, are challenging the medium- and long-term sustainability of healthcare systems worldwide.

We believe a strategic movement from volume to value-oriented healthcare is needed. By volume, we understand the continuously growing amount of health care expenditure as a critical response to the range of spending determinants. While value means healthcare efficiency approaches that may lead to the optimal relationship between the results and the system's inputs when a certain level of healthcare performance is attained in the best possible manner, which involves the minimum waste of time and effort.

In this work, we intended to investigate the concept of health care efficiency at macro and micro levels to contribute to the sustainability and resilience of modern health care systems. To address this aim, three research subjects were formulated:

1) The relationship between Life expectancy at birth and Health care expenditure
2) Health care expenditures disparities among high-income countries
3) The efficiency of health care as a strategic management

5.1.1 The relationship between Life expectancy at birth and Health care expenditure

It was a cross-country study where we used an own-built yearly dataset on 138 countries from 2000-2018. The data comprises health, macroeconomic, social, and institutional variables.

In this study, we aimed to contribute to the existing literature by comprehensively analysing the determinants of Life Expectancy at Birth. Specifically, we explored the relationship between LEB and healthcare expenditure indicators, considering the presence of alternative financial schemes. Our goal was twofold: to assess the importance of investment volume in determining healthcare outcomes and to investigate whether a different distribution of healthcare expenditure among these schemes impacts the outcomes. Additionally, we

examined various socio-economic variables and institutional quality indicators to identify potential areas for policy intervention to enhance healthcare.

In this part of the investigation, we tried to answer the following research questions:

a) Does the volume of health care expenditures affect LEB?
b) Does the financial scheme define the LEB?
c) What are the macroeconomic and social determinants of LEB?
d) Does institutional quality impact LEB?

Our results suggest that the volume of healthcare expenditures is essential for healthcare outputs, proxied by Life expectancy at birth. No clear-cut result is consistently obtained regarding the type of health financing beyond government expenditure. Regarding the determinants of LEB, our analysis reveals a negative correlation between certain socio-economic factors and Life Expectancy at Birth. Specifically, we find that GDP growth, Inflation, Unemployment rate, and the Gini index are inversely related to healthcare outcomes. This highlights the complex interplay between economic factors and health outcomes. More significantly, our research demonstrates a positive relationship between government effectiveness and health outcomes. This underscores the crucial role that institutional factors play in shaping healthcare outcomes.

The results of our baseline model indicated the existence of significant differences across countries by income group. To further explore these differences, we estimated separate regressions by income group: low-, low-middle, upper-middle, and high-income country groups.

Our study has revealed additional noteworthy findings. Firstly, voluntary spending has a particularly significant positive impact on healthcare outcomes in low-income countries. Secondly, the positive association between health spending per capita and Life Expectancy at Birth is evident mainly in low- and high-income countries. Thirdly, while the negative relationship between inflation and LEB holds for all income groups except low-income countries, the importance of government effectiveness is more pronounced in low-income countries, as expected.

Furthermore, our analysis shows that population density has a nuanced impact on healthcare outcomes. In countries with low-income levels, there is a positive relationship between Life Expectancy at Birth and population density, likely due to more accessible access to healthcare services. However, in more densely populated areas, there may be issues with overcrowding and a decline in health due to urbanization. This effect is more evident in low-income countries, while the variable loses its explanatory power for countries with higher income levels.

5.1.2 Health care expenditures and efficiency disparities among high-income countries

In this study, we aimed to determine whether the disparities in health outcomes among countries are related to differences in health expenditure or whether other factors unrelated to health activities are also contributing. We conducted a cross-sectional analysis of data from 37 high-income countries between 2000 and 2019, examining critical metrics of nine categories influencing healthcare spending. By identifying the drivers of health care expenditure, we hoped to identify potential avenues to improve health outcomes that are not dependent on increasing spending. Our goal was to contribute to understanding how to improve health care efficiency in countries with similar income levels but differing health outcomes. Additionally, we aimed to guide high-income countries on the most critical factors for improving health care efficiency.

The research questions we wanted to answer in this study were:

a) Why do healthcare expenditure disparities exist among countries with similar income levels?
b) What are the determinants of health care results of highly efficient health care systems?

Our study confirms that an ageing population is crucial to health outcomes disparities. Income inequality is found to hurt healthcare efficiency. The results showed that a lower percentage of health expenditure devoted to administration and governance contributes to better health outcomes. Lifestyle factors are highly influential in determining life expectancy. Specifically, a Mediterranean diet has a positive and significant effect, while alcohol consumption has a

negative and significant impact. Higher health research and development expenditure levels are associated with higher life expectancy. Moreover, higher levels of pharmaceutical spending are negatively associated with better health outcomes. Out-of-pocket health expenditure is a significant factor in ensuring better health outcomes within rich countries.

Several variables distinguish between different country groups in terms of healthcare efficiency. Countries with low efficiency tend to have higher social inequality and spend more on governance and healthcare and pharmaceutical goods administration. They also have a population with less healthy lifestyles and lower investment in R&D.

In contrast, high-efficiency countries have more economic stability and a younger population with healthier lifestyles. They invest more in R&D and spend less on administration functions of healthcare, as well as less on pharmaceuticals.

Intermediate efficiency countries show higher levels of social equality and institutional quality, with noticeably higher expenditure on prevention care. The quality of life of their population is moderate, and out-of-pocket spending is the lowest among all the efficiency groups.

5.1.3 Efficiency of health care as a strategic management

The main objective of this study was to present a comprehensive understanding of healthcare efficiency as a strategic concept. We started by providing explicit definitions of the key terms related to healthcare efficiency and outlining the role of management in implementing efficiency measures. Next, we introduced a conceptual model of healthcare efficiency implementation as a strategic approach. We aimed to develop a framework that healthcare administrators can use to effectively manage the healthcare sector's challenges. To illustrate the application of this framework, we presented a case study of a medium-sized hospital in Spain, specifically focusing on its surgical area.

The research questions of this part of the study were:

a) Who is responsible for the efficiency of the healthcare system?
b) Is it possible to define efficiency implementation as a strategy?
c) What methodology may be used as a base for implementing healthcare efficiency?

d) What would be a conceptual framework of the strategy of health care efficiency implementation?
e) Does it work on a real case study?

In the current landscape, effective management of healthcare primarily involves a process of decision-making. Managers at various levels and in different contexts must make informed choices regarding the direction of their organization, the objectives they aim to achieve, the strategies they will employ, the allocation of resources, and the distribution of rewards. Making exceptional strategic decisions necessitates creativity and rationality, ultimately driving organisational innovation. Therefore, capable healthcare management is regarded as a critical and promising tool for implementing healthcare system efficiency.

The intricacy of the healthcare system complicates the standardized and unified approach to efficiency management. The PMI´s Standard for Program Management (PgMP) is an integrated and coherent methodology that would encompass the complexity of the healthcare system without harming local autonomy.

PMI defines *Program* as a collaborative group of related projects that cannot be managed individually. *Program* management is the centralized management of a *Program* to achieve strategic benefits and objectives. It allows for optimized cost, schedules, effort, integrated deliverables, incremental benefits, and staffing. *Programs* and *Program* management exist within a strategic context and operate as strategy implementation vehicles.

Innovative strategic management tools for healthcare managers should help find inefficiencies, implement necessary changes, and maintain healthcare efficiency. Solutions should align with global healthcare objectives while considering the local context.

The conceptual framework mainly consists of the *Program Preparation* and *Program Implementation*. The *Preparation* includes the following steps: *Efficiency analysis*, *Objectives definition*, *Benefits management,* and *Stakeholder's interests*. Then, the *Implementation* process starts and consists of the five stages of the Program Life Cycle: *Pre-program Set Up, Program Set Up, Establish Program Management & Technical Infrastructure, Deliver Incremental Benefit, Close the Program*. The Governance team should monitor all the stages of the Implementation of efficiency.

Applying the model to the actual case led us to estimate that the potential quantitative improvements within a surgery department may reach at least 360k euros in terms of annual economic savings by 1% of improvement in four categories of outcomes. Those are optimization of the department´s resources use, improvement of the surgery programming process, patients´ satisfaction and patient security.

Among the qualitative results potentially obtained from the adoption of the proposed solution, there stand the work process fluency of the surgery department units, reduction of the patients waiting time during the day of the operation, and, as a consequence of the increasing operations during the session, improvement of the waiting list.

5.2. Implications

"The routine is the enemy of analytical thinking."

Unknown author

5.2.1 Relevance of macroeconomic context to healthcare efficiency

One of the main findings of this study is that investigating or governing healthcare efficiency requires taking into account the macroeconomic context of the healthcare system being analysed. Efficiency is achieving maximum practical work while using the least energy, fuel, effort, etc. Every country, region, or healthcare provider has a unique geographic, socio-economic, and demographic context, which may also vary regarding resource availability and accessibility.

Our research suggests that governments and healthcare policymakers should consider additional mechanisms and policies to improve life expectancy at birth (LEB), given the significant impact of macroeconomic stability, institutional quality, human capital level, unemployment, and income inequality on LEB. A more comprehensive approach is needed to achieve targets such as a high LEB, improving health system efficiency, and addressing increasing pressures on the healthcare system due to population ageing or unexpected illnesses. This includes promoting education, reducing income inequality, maintaining economic stability, and improving institutional quality.

5.2.2 The role of healthcare expenditure in healthcare efficiency

Our research indicates that investing in healthcare systems is essential to improve life expectancy at birth, regardless of the country's income level. However, increasing healthcare expenditure does not necessarily equate to efficiency, especially among high-income countries. To achieve healthcare efficiency, policymakers must adopt a more comprehensive approach that considers macroeconomic factors, promotes healthy lifestyles, and funds healthcare research and development. Interestingly, our study shows that high healthcare expenditures on governance and administration and pharmaceutical spending can negatively impact healthcare system efficiency among high-income countries. Therefore, healthcare policymakers should carefully evaluate the most effective ways to allocate healthcare resources to maximize healthcare outcomes.

5.2.3 Management as the key to efficient healthcare

Healthcare managers are the key figures in efficiency implementation throughout healthcare. The peculiarity and complexity of the system, together with the current challenges, push them to look for innovative methods that could help them to perform in the best possible manner with the least waste of time and effort.

Our study suggests taking efficiency as a strategy at any healthcare system level. Moreover, derive it from the agile program management standards that may include the preparation, implementation, objective, and critical results monitoring systems from the stakeholders and government perspectives.

5.3. Suggestions for future research

5.3.1 Patient-centric medicine as a Response to an ageing population

It is already known that the ageing population is a crucial element of the healthcare system's future. The results of our study among high-income countries merely confirm the statement, showing that the ageing population is a crucial determinant of healthcare efficiency.

We suggest investigating patient-centric care in light of the vital and positive role of population lifestyle and healthcare R&D in healthcare efficiency. Patients may be responsible for caring about themselves thanks to health care literacy (healthy lifestyle promotion,

preventive medicine) and new technology provided (as a result of R&D) by health care systems. These may result from a move from reactive (dealing with the disease) to proactive medicine (anticipating the disease and improving quality of life) based on patient-centric care according to their demographic and socio-economic needs.

As our study showed a negative impact that we found between the level of health expenditure on prevention care and LEB, additional studies are needed in this area.

5.3.2 Government and Administration Expenditure: cost or investment?

The level of Government and Administration costs has long raised questions for many scientists. Our investigation of this variable within healthcare revealed that developed countries with lower healthcare efficiency tend to spend more than other groups on Governance and administration of the healthcare.

Also, World Government Indicators as Government Effectiveness showed different behaviours depending on the country's income level. It demonstrated a substantial impact on LEB within low- and middle-income countries. However, in the case of developed countries, its impact does not seem relevant to explain healthcare outputs.

We suggest continuing to investigate the role of Government and Administration in healthcare efficiency, including the perspective of the countries´ income level and other socioeconomic indicators. In addition, we believe that in the case of developed countries, an extreme point may exist from which the investment in administration and governance becomes an expense.

In addition, standardized metrics are necessary globally to measure and investigate the return on investment in these areas.

5.3.3 Pharmaceuticals

Pharmaceutical spending forms an essential share of the total healthcare expenditures among all countries. Over the past few years, pharmaceutical consumption has sharply increased due to the ageing population and chronic diseases. However, due to the current financial threat to the healthcare system, the issue of pricing policy regarding pharmaceutical products arises.

For instance, the prices of some medicines for chronic diseases noticeably vary among the countries.

In light of our results that showed a strong negative impact of pharmaceutical spending on healthcare efficiency, we suggest investigating ways of optimising pharmaceutical spending.

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APPENDIX I AUXILIARY TABLES

Table A. 1 List of countries included in the analysis

Albania	Ghana	Netherlands
Algeria	Greece	Nicaragua
Angola	Guatemala	Nigeria
Argentina	Guinea	Norway
Armenia	Guinea-Bissau	Pakistan
Australia	Guyana	Panama
Austria	Haiti	Paraguay
Azerbaijan	Honduras	Peru
Bangladesh	Hungary	Philippines
Belarus	Iceland	Poland
Belgium	India	Portugal
Belize	Indonesia	Romania
Benin	Iran, Islamic Rep.	Russian Federation
Bolivia	Iraq	Rwanda
Bosnia and Herzegovina	Ireland	Samoa
Brazil	Israel	Senegal
Bulgaria	Italy	Serbia
Burkina Faso	Jamaica	Sierra Leone
Cabo Verde	Japan	Slovenia
Cameroon	Jordan	South Africa
Canada	Kazakhstan	Spain
Chad	Kenya	Sri Lanka
Chile	Korea, Rep.	St. Lucia

China	Kyrgyz Republic	Sudan
Colombia	Lao PDR	Suriname
Comoros	Latvia	Sweden
Congo, Rep.	Lebanon	Switzerland
Costa Rica	Lesotho	Tajikistan
Cote d'Ivoire	Liberia	Tanzania
Croatia	Lithuania	Thailand
Cyprus	Luxembourg	Timor-Leste
Czech Republic	Madagascar	Togo
Denmark	Malawi	Tonga
Djibouti	Malaysia	Tunisia
Dominican Republic	Maldives	Turkey
Ecuador	Mali	Turkmenistan
Egypt, Arab Rep.	Malta	Uganda
El Salvador	Mauritania	Ukraine
Estonia	Mauritius	United Arab Emirates
Ethiopia	Mexico	United Kingdom
Finland	Moldova	United States
France	Mongolia	Uruguay
Gabon	Morocco	Uzbekistan
Gambia, The	Myanmar	Venezuela, RB
Georgia	Namibia	Yemen, Rep.
Germany	Nepal	Zambia

Table A. 2 Example of the calculation of missing value for Gini index

	A	B	C	D	E
1	**country**	**year**	**gini**	**calculations**	**gini_fill**
2	ALBANIA	1995	27		27
3	ALBANIA	1996	27		27
4	ALBANIA	1997	N/A	=(1/5)*(D$9-D3)+D3	27,94
5	ALBANIA	1998	N/A	=(1/5)*(D$9-D4)+D4	28,692
6	ALBANIA	1999	N/A	=(1/5)*(D$9-D5)+D5	29,2936
7	ALBANIA	2000	N/A	=(1/5)*(D$9-D6)+D6	29,77488
8	ALBANIA	2001	N/A	=(1/5)*(D$9-D7)+D7	30,1599
9	ALBANIA	2002	31,7		31,7
10	ALBANIA	2003	N/A	=(1/2)*(D$12-D9)+D9	31,15
11	ALBANIA	2004	N/A	=(1/2)*(D$12-D10)+D10	30,875
12	ALBANIA	2005	30,6		30,6
13	ALBANIA	2006	N/A	=(1/2)*(D$15-D12)+D12	30,3
14	ALBANIA	2007	N/A	=(1/2)*(D$15-D13)+D13	30,15
15	ALBANIA	2008	30		30
16	ALBANIA	2009	N/A	=(1/3)*(D$19-D15)+D15	29,66667
17	ALBANIA	2010	N/A	=(1/3)*(D$19-D16)+D16	29,44444
18	ALBANIA	2011	N/A	=(1/3)*(D$19-D17)+D16	29,2963
19	ALBANIA	2012	29		29
20	ALBANIA	2013	29		29
21	ALBANIA	2014	29		29
22	ALBANIA	2015	29		29

Table A. 3 Years and a country fixed effect for OLS and Panel data estimates in Table 2.5

yr2001	0.242		
	(0.238)		
yr2002	0.442	0.209	0.209
	(0.232)*	(0.236)	(0.173)
yr2003	0.688	0.430	0.430
	(0.228)***	(0.231)*	(0.174)**
yr2004	1.120	0.781	0.781
	(0.224)***	(0.226)***	(0.176)***
yr2005	1.385	1.115	1.115
	(0.222)***	(0.218)***	(0.181)***
yr2006	1.648	1.440	1.440
	(0.220)***	(0.217)***	(0.186)***
yr2007	1.912	1.689	1.689
	(0.218)***	(0.215)***	(0.192)***
yr2008	2.325	1.991	1.991
	(0.218)***	(0.216)***	(0.200)***
yr2009	2.669	2.430	2.430
	(0.235)***	(0.219)***	(0.207)***
yr2010	3.130	2.763	2.763
	(0.232)***	(0.238)***	(0.219)***
yr2011	3.564	3.252	3.252
	(0.244)***	(0.238)***	(0.219)***
yr2012	3.871	3.587	3.587
	(0.259)***	(0.251)***	(0.225)***

yr2013	4.223	3.924	3.924
	(0.276)***	(0.267)***	(0.233)***
yr2014	4.587	4.268	4.268
	(0.298)***	(0.284)***	(0.242)***
yr2015	4.834	4.491	4.491
	(0.316)***	(0.308)***	(0.251)***
yr2016	5.195	4.820	4.820
	(0.336)***	(0.324)***	(0.260)***
yr2017	5.434	5.114	5.114
	(0.351)***	(0.346)***	(0.271)***
yr2018	5.647	5.336	5.336
	(0.368)***	(0.361)***	(0.280)***
AGO	-2.652	-14.935	
	(1.359)*	(2.500)***	
ALB	17.988	6.083	
	(0.939)***	(2.005)***	
ARE	14.847	2.561	
	(0.991)***	(1.835)	
ARG	17.160	4.938	
	(0.792)***	(2.080)**	
ARM	13.616	1.778	
	(1.048)***	(1.999)	
AUS	18.958	7.058	
	(1.176)***	(1.995)***	
AUT	19.646	7.685	
	(0.995)***	(1.799)***	
AZE	0.000	0.000	

	(.)	(.)
BDI	-2.486	-14.699
	(1.564)	(2.300)***
BEL	19.021	7.068
	(1.030)***	(1.445)***
BEN	0.323	-11.960
	(1.274)	(2.377)***
BFA	-1.855	-14.096
	(1.474)	(2.527)***
BGD	5.074	-6.920
	(1.884)***	(1.311)***
BGR	14.659	2.676
	(0.876)***	(2.000)
BHR	0.000	0.000
	(.)	(.)
BIH	0.000	0.000
	(.)	(.)
BLR	0.000	0.000
	(.)	(.)
BLZ	12.954	1.011
	(0.994)***	(2.235)
BOL	9.687	-2.301
	(0.916)***	(2.273)
BRA	14.024	1.754
	(0.757)***	(2.085)
BRN	0.000	0.000
	(.)	(.)

BTN	0.000	0.000
	(.)	(.)
BWA	-2.139	-13.873
	(1.431)	(2.511)***
CAN	18.398	6.539
	(1.244)***	(2.018)***
CHE	19.830	7.999
	(1.157)***	(1.734)***
CHL	19.442	7.465
	(0.766)***	(2.063)***
CHN	15.289	3.143
	(0.881)***	(2.008)
CIV	-2.393	-15.005
	(1.184)**	(2.350)***
CMR	-2.784	-14.999
	(1.185)**	(2.360)***
COD	1.778	-10.709
	(1.229)	(2.412)***
COL	18.087	5.843
	(0.688)***	(2.187)***
COM	0.000	0.000
	(.)	(.)
CPV	0.000	0.000
	(.)	(.)
CRI	18.819	6.773
	(0.987)***	(2.156)***
CYP	21.409	9.298

	(0.839)***	(1.871)***
CZE	15.051	3.689
	(1.559)***	(2.377)
DEU	18.868	7.010
	(1.077)***	(1.722)***
DJI	0.000	0.000
	(.)	(.)
DNK	15.686	3.895
	(1.272)***	(1.761)**
DOM	12.672	0.424
	(0.847)***	(1.928)
DZA	16.375	4.234
	(1.044)***	(2.195)*
ECU	16.842	4.623
	(0.899)***	(2.138)**
EGY	12.598	0.314
	(1.071)***	(2.081)
ERI	0.000	0.000
	(.)	(.)
ESP	19.560	7.869
	(1.110)***	(2.083)***
EST	15.168	3.497
	(0.984)***	(2.091)*
ETH	1.508	-10.372
	(1.654)	(2.616)***
FIN	17.963	6.173
	(1.141)***	(1.913)***

FJI	7.133	-5.038
	(1.076)***	(2.170)**
FRA	21.711	9.667
	(0.831)***	(1.812)***
FSM	0.000	0.000
	(.)	(.)
GAB	3.164	-8.884
	(0.913)***	(2.181)***
GBR	16.396	4.570
	(1.302)***	(1.681)***
GEO	0.000	0.000
	(.)	(.)
GHA	1.584	-10.460
	(0.995)	(2.105)***
GIN	0.000	0.000
	(.)	(.)
GMB	-0.550	-13.082
	(1.316)	(2.363)***
GNB	0.000	0.000
	(.)	(.)
GNQ	0.000	0.000
	(.)	(.)
GRC	21.796	9.772
	(0.862)***	(1.869)***
GRC	13.379	0.978
	(1.018)***	(2.163)
GUY	8.986	-3.047

	(0.898)***	(2.181)
HND	15.275	2.963
	(0.937)***	(2.206)
HRV	15.591	3.757
	(1.017)***	(1.888)**
HTI	0.613	-11.808
	(1.332)	(2.155)***
HUN	15.247	3.327
	(0.901)***	(1.897)*
IDN	9.491	-2.637
	(1.001)***	(2.065)
IND	5.734	-6.300
	(1.203)***	(1.778)***
IRL	18.265	6.237
	(0.951)***	(1.825)***
IRN	15.694	3.427
	(0.888)***	(2.104)
IRQ	11.230	-1.120
	(1.281)***	(2.226)
ISL	20.120	8.085
	(1.133)***	(1.902)***
ISR	19.583	7.779
	(1.079)***	(1.618)***
ITA	21.038	8.950
	(1.037)***	(1.664)***
JAM	13.994	1.857
	(0.974)***	(1.822)

JOR	13.690	1.634
	(0.939)***	(1.987)
JPN	23.027	11.078
	(1.074)***	(1.550)***
KAZ	8.896	-3.010
	(1.122)***	(2.155)
KEN	0.307	-11.669
	(1.270)	(2.389)***
KGZ	10.962	-0.970
	(1.180)***	(2.252)
KIR	0.000	0.000
	(.)	(.)
KOR	17.208	5.455
	(1.159)***	(1.344)***
KWT	0.000	0.000
	(.)	(.)
LAO	6.013	-6.262
	(1.275)***	(2.397)***
LBN	0.000	0.000
	(.)	(.)
LBR	3.335	-9.153
	(1.477)**	(2.336)***
LBY	0.000	0.000
	(.)	(.)
LCA	0.000	0.000
	(.)	(.)
LKA	13.063	0.861

	(0.964)***	(1.716)
LSO	-12.360	-24.513
	(1.059)***	(2.242)***
LTU	14.252	2.307
	(0.866)***	(2.019)
LUX	19.672	7.700
	(0.922)***	(1.668)***
LVA	12.072	0.216
	(0.981)***	(1.979)
MAR	15.480	3.305
	(1.075)***	(2.194)
MDA	11.027	-0.982
	(0.999)***	(2.074)
MDG	4.892	-7.405
	(1.282)***	(2.449)***
MDV	9.705	-2.374
	(1.903)***	(1.045)**
MEX	16.498	4.219
	(0.899)***	(2.086)**
MLI	-3.179	-15.388
	(1.499)**	(2.587)***
MLT	11.861	0.000
	(2.078)***	(.)
MMR	7.193	-5.106
	(1.404)***	(2.458)**
MNG	8.597	-3.379
	(1.013)***	(2.198)

MOZ	-4.932	-17.413
	(1.548)***	(2.677)***
MRT	5.516	-6.767
	(1.267)***	(2.405)***
MUS	10.268	-1.860
	(1.235)***	(1.217)
MWI	-4.918	-16.857
	(1.567)***	(2.513)***
MYS	13.402	1.359
	(0.929)***	(1.952)
NAM	-4.050	-16.257
	(0.981)***	(2.307)***
NER	-0.746	-12.968
	(1.584)	(2.640)***
NGA	-7.727	-19.988
	(1.221)***	(2.202)***
NIC	14.771	2.461
	(0.983)***	(2.250)
NLD	18.123	6.102
	(1.145)***	(1.288)***
NOR	18.246	6.405
	(1.297)***	(1.952)***
NPL	8.530	-3.693
	(1.345)***	(2.259)
NZL	0.000	0.000
	(.)	(.)
OMN	0.000	0.000

	(.)	(.)
PAK	6.561	-5.717
	(1.334)***	(2.138)***
PAN	18.395	6.066
	(0.809)***	(2.080)***
PER	15.817	3.684
	(0.863)***	(2.185)*
PHL	9.785	-2.468
	(1.014)***	(1.846)
PNG	0.000	0.000
	(.)	(.)
POL	17.009	5.149
	(0.864)***	(1.931)***
PRT	18.778	6.618
	(0.914)***	(1.764)***
PRY	14.802	2.492
	(0.927)***	(2.250)
QAT	0.000	0.000
	(.)	(.)
ROU	15.554	3.523
	(0.852)***	(2.066)*
RUS	9.865	-2.108
	(0.975)***	(2.156)
RWA	-0.264	-12.135
	(1.446)	(2.007)***
SAU	0.000	0.000
	(.)	(.)

SDN	6.986	-5.513
	(1.396)***	(2.466)**
SEN	14.715	2.180
	(1.257)***	(2.368)
SGP	0.000	0.000
	(.)	(.)
SLB	0.000	0.000
	(.)	(.)
SLE	-7.008	-19.343
	(1.399)***	(2.389)***
SLV	11.781	-0.542
	(0.964)***	(1.836)
SRB	3.054	-8.751
	(0.935)***	(1.936)***
SUR	0.000	0.000
	(.)	(.)
SVN	17.548	6.048
	(1.277)***	(2.105)***
SWE	19.014	7.143
	(1.224)***	(1.911)***
SYC	0.000	0.000
	(.)	(.)
TCD	0.000	0.000
	(.)	(.)
TGO	-0.104	-12.349
	(1.309)	(2.395)***
THA	13.456	1.350

	(0.922)***	(1.954)
TJK	9.195	-2.396
	(1.185)***	(2.270)
TKM	0.000	0.000
	(.)	(.)
TLS	0.000	0.000
	(.)	(.)
TON	0.000	0.000
	(.)	(.)
TUN	16.440	4.301
	(0.884)***	(2.040)**
TUR	15.988	3.847
	(0.789)***	(2.022)*
TZA	-0.938	-12.829
	(1.333)	(2.429)***
UGA	-4.137	-16.110
	(1.283)***	(2.252)***
UKR	10.125	-1.829
	(1.131)***	(2.055)
URY	17.476	5.205
	(0.725)***	(2.034)**
USA	16.799	4.636
	(1.084)***	(1.990)**
UZB	0.000	0.000
	(.)	(.)
VEN	15.473	2.817
	(0.930)***	(2.156)

VUT	0.000	0.000
	(.)	(.)
WSM	0.000	0.000
	(.)	(.)
YEM	7.748	-4.589
	(1.357)***	(2.397)*
ZAF	0.000	-12.117
	(.)	(2.165)***
ZMB	-4.389	-16.172
	(1.342)***	(2.520)***

Table A. 4 Years fixed effect for Panel data estimates by income groups in Table 2.6

	Low		**Low-middle**		**Upper middle**		**High**	
	Equivalent col., Table 3:		Equivalent col., Table 3:		Equivalent col., Table 3:		Equivalent col., Table 3:	
	Col (5)	Col.(6)	Col (5)	Col.(6)	Col (5)	Col.(6)	Col (5)	Col.(6)
yr2002		0.429		0.387		-0.075		0.064
		(0.266)		(0.181)**		(0.403)		(0.099)
yr2003		0.738		0.713		0.048		0.094
		(0.269)***		(0.184)***		(0.411)		(0.101)
yr2004		0.998		0.998		0.129		0.509
		(0.279)***		(0.195)***		(0.413)		(0.101)***
yr2005		1.721		1.309		0.399		0.616
		(0.303)***		(0.203)***		(0.424)		(0.103)***
yr2006		2.381		1.649		0.787		0.774
		(0.321)***		(0.216)***		(0.432)*		(0.106)***
yr2007		2.720		2.050		1.147		0.887
		(0.338)***		(0.228)***		(0.464)**		(0.110)***
yr2008		3.202		2.332		1.642		1.080
		(0.355)***		(0.252)***		(0.486)***		(0.115)***
yr2009		3.891		2.830		2.161		1.239
		(0.377)***		(0.275)***		(0.509)***		(0.124)***
yr2010		4.541		3.010		2.198		1.309
		(0.411)***		(0.288)***		(0.533)***		(0.142)***
yr2011		4.885		3.597		2.979		1.622
		(0.427)***		(0.288)***		(0.545)***		(0.135)***
yr2012		5.310		4.100		3.350		1.676
		(0.448)***		(0.303)***		(0.578)***		(0.139)***

yr2013	5.962	4.495	3.585	1.831
	(0.471)***	(0.319)***	(0.602)***	(0.146)***
yr2014	6.704	4.908	3.939	2.049
	(0.500)***	(0.332)***	(0.632)***	(0.154)***
yr2015	7.009	5.334	4.206	1.910
	(0.516)***	(0.348)***	(0.661)***	(0.162)***
yr2016	7.452	5.804	4.327	2.100
	(0.535)***	(0.363)***	(0.699)***	(0.167)***
yr2017	7.701	6.406	4.756	2.121
	(0.571)***	(0.377)***	(0.727)***	(0.176)***
yr2018	8.098	6.812	4.907	2.183
	(0.597)***	(0.394)***	(0.757)***	(0.184)***

Table A. 5 List of countries included in the analysis

Countries		
Australia	Hungary	Norway
Austria	Iceland	Poland
Belgium	Ireland	Portugal
Canada	Israel	Slovak Republic
Chile	Italy	Slovenia
Colombia	Japan	Spain
Czech Republic	Korea	Sweden
Denmark	Lithuania	Switzerland
Estonia	Latvia	Turkey
Finland	Luxembourg	United Kingdom
France	Mexico	United States
Germany	Netherlands	
Greece	New Zealand	

Table A. 6 Variables analysed in the robustness checks

Variable	Abbreviation	Description	Mean	Standard Deviation	Min	Max	Missing, %	Source
Life expectancy at birth	leb	total (years)	78.816	3.114	70.005	84.211	0%	WDB
HCE % gdp	hcegdp	as % Gross Domestic Product (GDP)	8.266	2.142	3.898	17.049	0%	WDB
Macroeconomic (B1)								
Gini index	gini	0 (perfect equality) to 100 (perfect inequality)	33.643	6.462	23.700	58.700	3%	WDB
General government debt	ggd	as % Gross Domestic Product (GDP)	72.643	42.686	6.649	238.726	0%	
Credit to Private non-financial sector from All sectors at Market value	crpr	Percentage of GDP - Adjusted for breaks	216.785	80.404	42.525	452.425	16%	
Real GDP growth	gdp	annual growth, constant 2010 USD	2.573	3.168	-14.814	25.163	0%	WDB
Government Effectiveness	wgige	-2,5 to 2,5	1.192	0.779	-2.085	2.354	0%	WGI
Voice and Accountability	wgiva	-2,5 to 2,5	1.113	0.460	-0.831	1.801	0%	WGI
Political Stability No Violence	wgipsnv	-2,5 to 2,5	0.668	0.743	-2.374	1.760	0%	WGI
Regulatory Quality	wgirq	-2,5 to 2,5	1.251	0.471	-0.087	2.098	0%	WGI
Rule of Law	wgirl	-2,5 to 2,5	1.221	0.668	-0.889	2.100	0%	WGI
Control of Corruption	wgicc	-2,5 to 2,5	1.211	0.829	-0.927	2.469	0%	WGI
Average WGI	avwgi	-2,5 to 2,5	1.109	0.591	-0.654	1.969	0%	WGI
Demography (B2)								
Population	pop	inhabitants					0%	
Population > 65 years	pop65	% of population	15.041	4.076	4.742	27.475	0%	WDB
Rural population	rpopden	% of total population	23.530	11.096	1.999	49.246	0%	WDB
Healthcare expenditure by function (B3)								
Primary Health Care	phce	Expenditure as % Current Health Expenditure (CHE)	40.999	4.599	33	49	94%	

Preventive care	pchce	Share of current expenditure on health	2.714	1.193	0.022	6.818	17%	OECD
Inpatient curative and rehabilitation care	ichce		26.744	5.056	16.350	44.727	21%	
Outpatient curative and rehabilitation care	ochce		27.374	6.651	14.924	47.701	18%	
Long-term care	lthce		12.076	8.198	0.006	29.262	22%	
Ancillary services	ashce		4.704	2.367	0.293	12.864	24%	
Medical goods	mghce	Share of current expenditure on health	21.091	7.060	9.787	45.638	17%	OECD
Governance and administration	gahce	Share of current expenditure on health	3.205	2.003	0.456	12.975	17%	OECD
Population health (B4)								
Tobacco consumption	tc	% of population aged 15+ who are daily smokers	20.615	5.650	7.6	40	47%	
Alcohol consumption	ac	Litres per capita (15+)	9.257	2.858	1.2	14.800	1%	OECD
Obese population	op		19.856	10.765	2.9	40	83%	OECD
Mediterranean diet	mdiet	Index	0.216	0.412	0	1	0%	OECD
Health care resources (B5)								
Health care resources Index	index_hcr	Index	-0.148	1.482	-23.755	4.092	8%	OECD
Practising workforce: nurses	pn	Density per 1 000 population (head counts)	8.003	3.712	.49	17.740	26%	
Practising workforce: Practising physicians	pp	Density per 1 000 population (head counts)	3.068	0.764	1.230	5.240	20%	
Practising workforce: Generalist medical practitioners	gmp	Density per 1 000 population (head counts)	0.954	0.472	.25	3.220	20%	
Practising workforce: Specialist medical practitioners	smp	Density per 1 000 population (head counts)	1.985	0.667	.55	5.140	23%	
Workforce remuneration: hospital nurses	rhn	Salaried, income, US$ PPP	42.933.500	18.190.490	6.705.7	1.14e+	39%	
Remuneration of general practitioners	rgp		76.048.330	46.967.260	20.832	3.66e	71%	

Remuneration of specialists	rs		98.577.930	50.824.680	9.487.2	2.93e+	46%	
Non-health-specific average annual wages	aaw		38.006.020	13.249.6	10.987	66.504	5%	
Equipment: magnetic resonance imaging units	mr	Per million population	11.384	8.942	.09	55.210	28%	
Equipment: Computed tomography scanners units	ct	Per million population	20.606	14.265	.07	111.49	23%	
Mammography machine units	mm		21.878	13.054	2.820	65.970	41%	
Radiation therapy equipment units	rt		6.797	3.529	.88	16.940	43%	
Hospital beds	hb		1.77e+05	3.36e+05	1014	1864008	6%	
Long-term care beds	lthb		27.232.190	71.474.2	0	383911	30%	
Health care utilization (B6)								
Health care utilization Index	index_hcru	Index	-0.008	0.894	-7.086	4.129	11%	OECD
Discharges: Mental behavioural	dmb	Per 100 000 population	657.612	450.067	37.700	1.798.90	17%	
Acute myocardial infarction	dam		176.528	77.454	11.600	426.600	17%	
Pneumonia	dp		315.918	137.163	62.600	829	17%	
Chronic obstructive Pulmonary disease and bronchiectasis	dpd		196.109	81.847	24.800	433.100	19%	
Examinations: Magnetic resonance imaging units	emr	Per 1 000 population	52.575	31.176	3.1	149.200	55%	
Computed tomography	ect		124.530	56.259	27.900	325	53%	
Surgical procedures: Total knee replacement	skr	Per 100 000 population	110.520	58.842	2.9	257.900	37%	
Surgical procedures: Cataract surgery	scat	Per 100 000 population	722.600	321.774	37.800	1656	28%	
Total hip replacement	shr		160.132	73.725	4.1	313.700	33%	
Hysterectomy	sh		205.605	72.793	12.300	377	36%	
Cesarean delivery	sce		534.403	229.212	196.30	1.806.60	31%	
Coronary artery bypass graft surgery	cca		45.301	20.933	1.3	132	33%	
Length of stay per capita: Acute myocardial infarction	lsm	Days	7.528	1.967	3.3	18.200	18%	
Pharmaceutical spending (B7)								

Pharmaceutical spending	pshce	% of health spending	17.907	6.740	6.329	40.239	17%	OECD
Public spending	pps		61.593	14.611	33.233	85.121	84%	
Private Insurance Scheme	ppris		3.306	6.852	0	34.430	84%	
Private out-of-pocket spending	popps		34.596	15.052	6.995	66.360	84%	
Volume	gvol		19.208	11.755	.1	49.600	74%	
Value	gval		36.645	21.084	.2	76.800	72%	
Antibiotic prescribing	ap	Defined daily dosage per 1 000 inhabitants per day	19.155	6.046	9.1	42.300	27%	
Access, distribution and equity (B8)								
Too expensive	unte		1.930	2.891	0	15.100	68%	
Too far to travel	unteft		0.174	0.239	0	1.1	68%	
Too expensive or too far to travel or waiting list	unet		3.358	3.656	0	16.400	68%	
No time	unnt		0.589	0.638	0	2.3	68%	
No unmet needs to declare	nun		94.085	4.721	77.900	99.800	68%	
Out-of-pocket spending	hceoopp	% Current health expenditure	20.886	9.305	7.138	55.664	0%	WDB
Innovation (B9)								
Research and development expenditure	rd	% of GDP	1.797	1.038	0.130	4.953	0%	WDB
Gross domestic R&D expenditure on health (health GERD)	hrd		0.107	0.066	.03	.31	98%	
Government budget allocations for R&D, R&D related to Medical and health sciences - financed from GUF General University Funds	ghrdguf		627.923	956.216	0	3.515.199	86%	
Government budget allocations for R&D, R&D related to Medical and health sciences - financed from sources other than UF General Uiversity Funds	ghrd		163.373	223.797	0.968	918.189	84%	
GERD - Medical and health sciences	hgerd		10.735	5.030	2.570	30.158	74%	
GLOBAL INNOVATION INDEX	gii		50.601	8.247	30.450	68.400	59%	
eHealth (B10)								

Has national legislation, strategy or policy on the use of telemedicine in 2018?	tms		0.788	0.415	0	1	95%	
Defines jurisdiction, liability or reimbursement of eHealth services (e.g. telehealth)	tmr		0.742	0.445	0	1	96%	
eHealth composite indices between 2013 and 2018	ehci		1.954	0.316	1.346	2.673	94%	
Data availability	didav	0-100	0.191	0.063	0.066	0.316	5%	OECD
Data accessibility	didac	0-100	0.226	0.052	0.057	0.322	5%	OECD
Government Support to re-use	digs	0-100	0.165	0.076	0	0.333	5%	OECD
OURData Index global	dig	0-100	0.581	0.166	0.126	0.943	5%	OECD
snomed	snomed		0.703	0.457	0	1	0%	

APPENDIX II RETURN ON INVESTMENT

Usually, the most striking improvement area in surgery departments might be the performance of the operating rooms.

According to the studies [139], every 1% below 85% of the operating room's performance is converted into costs, between €7500 and €12000 per operating room per year, or an average of 9750 €. Since it seems evident that this cost depends on the number of procedures in the standard operation room, and considering that we are dealing with a medium size hospital, we assume that average for our calculations.

According to the performance reports of the potential artificial intelligence tools producer, their product improves the performance by more than 10% during the first year of its use at the hospital. Nevertheless, being conservative again, we offer our basic calculation for a 1% improvement, with no assumption for the total impact of the AI tool in our case study. On the other hand, the cost of that AI tool situates around €8000 per unit as it is newly installed. The subscription adds an additional €1000 per unit from the second year. It means we estimate the cost for the AI tool as follows:

Product cost for the first year =8000*13=104 000€

Product cost for every following year =1000*13=13 000€

Under all the previous assumptions, the gain coming from this innovation ***for the first 1% increase*** in all 13 operating room performances during the first year is:

Net result for the AI tool implementation (first year) = (9750-8000)*13 = €22750

The calculation of the Return on Investment (ROI) using the usual formulation, where ROI = [(Gain from the investment – Cost of investment) / Cost of Investment], gives us the following result:

ROI for every 1% improvement during the first year: 22750/104000 = 21.9%

This result by itself would justify the implementation of the new tool. Note that any additional improvement, 5% in all the operating room performance, would imply an ROI of more than 500% in the first year (since the main cost is fixed). However, even more

rewarding, assuming the initial improvement can be sustained (or even increased) during the following years (and with a mere additional cost of around €13000 due to the subscription fee), the final net result for the hospital in the medium term could pile up millions of euros.