



## EFFICIENCY OF HEALTH EXPENDITURE IN ORGANIZATION OF ISLAMIC COOPERATION (OIC) COUNTRIES: A DATA ENVELOPMENT ANALYSIS APPROACH

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### ABSTRACT

Studies concerning the efficiency of health spending rank among the primary priorities in global policies aimed at enhancing health equity through improved health services and care. This study focuses on countries belonging to the Organization of Islamic Cooperation (OIC) due to their limited access to healthcare, government health spending, and increasing out-of-pocket expenditure. The study aims to measure efficiency scores of healthcare expenditure in OIC member countries. This research is a quantitative study using a Data Envelopment Analysis (DEA) approach. This study using two variables this input and output variables. Input variables are such as total health expenditures, government health expenditures, and out-of-pocket health expenditures per capita PPP current International \$, while output variables include life expectancy and infant mortality per 1,000 births. All variables are secondary data derived from World Development Indicators (WDI) in World Bank. The research sample comprises 50 out of 57 OIC countries during 2004-2018. Results indicate that the average efficiency score of OIC countries from 2004 to 2018 was 0.551. Predominantly, countries in the Middle East demonstrated the highest efficiency scores, with Qatar leading followed by Brunei Darussalam, Kuwait, UAE, and Saudi Arabia, while Egypt recorded the lowest efficiency score. Based on this research, OIC countries are encouraged to diversify government-owned insurance policies, allocate government health expenditures more precisely, reduce the stunting rate among children, protect the health of pregnant women, and promote health investments.

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## 1. INTRODUCTION

Healthcare expenditure efficiency is one of the top priorities worldwide (Grigoli & Kapsoli, 2013), The World Health Organization (WHO) has established that besides equity and utility, efficiency is also a fundamental criterion in allocating healthcare resources (WHO, 2003). The primary goal of efficiency is to maximize health levels within the allocated budget to achieve global uniformity in healthcare services and treatments (Liu et al., 2019).

Efficiency in healthcare expenditure has been a longstanding concept in health economics theory (Jakovljevic et al., 2021), and current policies are related to the direct effects of population aging, which is a crucial factor in healthcare expenditure increases (de Meijer et al., 2013). World Development Indicators (WDI) data from World Bank (World Bank, 2023) shows that there has been a doubling of healthcare expenditure per capita globally from US\$ 520 in 2002 to US\$ 1,115 in 2019, or about 9.8 percent of total GDP. Approximately 80 percent of this expenditure comes from High-Income Countries (HICs), with 70 percent from government budgets. In contrast, for Low-Income Countries (LICs), 44 percent of healthcare expenditure comes from out-of-pocket payments and 29 percent from external aid (WHO, 2022).

The increase in healthcare expenditure has become an important issue as a benchmark for assessing the performance of healthcare resources used through the input and output framework (Afonso & Aubyn, 2005). González et al. (González et al., 2010) argue that the quantity or weight of healthcare spending and public budget are positively related inputs to healthcare system performance as part of the efficiency process. Additionally, healthcare services (Worthington, 2004) and healthcare services (Hollingsworth et al., 1999) are indispensable components of healthcare efficiency as healthcare costs continue to rise, influencing public expenditure. Yu et al. (Yu & Tang, 2019) state that addressing inefficiencies in healthcare service system performance impacts economic development. Murova (Murova, 2017) states that in economic growth, an excess of labor beyond the optimal limit actually reduces the Gross State Product (GSP); in this case, excess labor serves as a form of inefficiency leading to a decrease in GSP.

Efficiency in healthcare expenditure will be a challenge and problem in achieving healthcare service uniformity (Jakovljevic et al., 2021) in OIC countries, given that the majority of OIC countries are in the low-to-middle-income economic condition. Wahab et al. (A. Wahab et al., 2018) argue that among the factors contributing to this challenge are gaps in healthcare assurance and services, inadequate protection of resources, and financing infrastructure that does not align with international health guidelines and principles. Another study by Wahab et al. (A. A. O. A. Wahab et al., 2019) suggests that among the various determinants of healthcare expenditure, healthcare services in OIC countries are considered luxury goods. Lavado & Cabanda (Lavado & Cabanda, 2009) add that healthcare expenditure is relatively high compared to national income, and the importance of examining expenditure-saving measures in developing countries seems yet to be realized. This research focuses on Muslim-majority countries within the OIC, the second-largest organization after the UN, with 57 member countries spread across four continents, serving as a forum to safeguard and protect the interests of the Muslim world (OIC, 2023). Based on available data, total healthcare expenditure in OIC countries accounts for only 3.5 percent of the world's total healthcare expenditure (US\$ 227.2 billion), which is disproportionate to their population share of 22.8 percent of the global population. For healthcare budgets, 57 percent of total expenditure comes from governments and 36 percent from self-financing, while for developed countries, 65 percent comes from governments and 14 percent from self-financing, with out-of-pocket payments being more than twice as large as those in other developed countries (SESRIC, 2014).

Previous studies have looked at healthcare spending efficiency, with a focus on different aspects. Chen et al. (2021) studied 15 major economies and found that healthcare spending increased post-Covid-19, but efficiency varied. Countries like China, India, and Russia had lower efficiency due to lower spending, while the U.S., with higher spending, showed better efficiency. Meanwhile, Liu (2019) analyzed healthcare spending in China, noting rural areas lagging behind. He suggested improvements in service quality, resources, and policies. Hsu (2014) studied 46 countries in Central Asia and Europe, finding high efficiency but only a slight increase in output. Ahmed et al. (Ahmed et al., 2019) measured the efficiency of healthcare systems in Asian countries, with 91.3 percent of countries being declared inefficient. Yari et al. (Yari et al., 2023) measured the level of efficiency in Iran, accompanied by factors influencing it such as public health expenditure (as a percentage of GDP), GDP per capita, corruption control, education, and population density. Meanwhile Novignon (Novignon, 2015) examined the influence of public institution quality and corruption on the efficiency of public health expenditure in Sub-Saharan African regions.

Measuring efficiency is influenced by input and output factors. In regards to healthcare expenditure efficiency, some indicators include input indicators such as healthcare expenditure per capita (Hsu, 2014; Liu et al., 2019; Novignon, 2015) and total healthcare expenditure (% of GDP), while output indicators include several factors such as healthcare institutions, healthcare workers, healthcare facilities, and the level of healthcare resource utilization (Ahmed et al., 2019). Other output indicators include life expectancy (Novignon, 2015), infant mortality rate (Liu et al., 2019), and measles immunization coverage (% of children aged 12-23 months. Additionally, Zhang & Wang (2023) use different indicators. For input indicators, they include the number of institutions, beds, and healthcare workers. For output indicators, they include the number of cases in observation rooms, outpatient visits, emergency department facility level, inpatient operating time, discharged patients, health examinations, and inpatient numbers.

This study adds to previous research by including out-of-pocket healthcare spending as an input variable. Based on WDI data, out-of-pocket healthcare spending being more than twice as large as those in other developed countries (SESRIC, 2014). Other findings by Motaghi (Motaghi, 2016) highlight disparities in economic, geographic, and social factors, where GDP, literacy rates, malnutrition, out-of-pocket expenditures, and population serve as economic and social factors, while urbanization rates and CO2 emissions represent geographic factors in OIC countries, so these disparities affect access to and the health status. In addition, the increase in healthcare expenditures and the surge in chronic and critical illnesses in OIC countries highlight the need for healthcare spending efficiency (A. A. O. A. Wahab et al., 2019). The aim is to measure healthcare expenditure efficiency in OIC countries, helping improve healthcare systems over time.

## 2. RESEARCH METHODS

The data for this study were collected from the World Bank's World Development Indicators (WDI) and focused on 50 OIC member countries spanning from 2004 to 2018. It is an empirical research employing a quantitative approach, specifically descriptive quantitative research. The analysis used Data Envelopment Analysis (DEA) approach to examine input and output mechanism. The input variables used in this study are Per Capita Healthcare Expenditure, PPP (current International \$), Per Capita Domestic Government Healthcare Expenditure, PPP (current International \$), and Per Capita Out-of-Pocket Healthcare Expenditure, PPP (current International \$). Meanwhile, the output variables consist of Life Expectancy at Birth (total years) and Infant Mortality Rate (per 1,000 births).

The method used in this study to measure healthcare expenditure efficiency is Data Envelopment Analysis (DEA). DEA compares each observation, i.e., inputs and outputs, of the Decision Making Unit (DMU) to assess and evaluate public performance (Ouertani et al., 2018). In this study, the DMU refers to OIC member countries. DEA is a non-parametric technique that uses linear programming to calculate the production frontier for each of the 50 OIC countries. The function used in this analysis is as follows:

$$Y_i = f(X_i), i = 1, \dots, 50 \dots\dots\dots (1)$$

Where as:

- $Y$  : Composite output measure (per capita healthcare expenditure, per capita domestic government healthcare expenditure, and per capita out-of-pocket healthcare expenditure)
- $X$  : Composite input measure (life expectancy at birth, infant mortality rate per 1,000 births)
- $i$  : The observed country

The equation in this method indicates that inefficiency occurs if  $Y_i < f(X_i)$ , while  $Y_i > f(X_i)$  indicates that the output value is greater than the input value, indicating that the observed result has achieved efficiency. Efficiency scores are typically expressed between 0 and 1 or 0 and 100 percent, with scores less than 1 or 100 percent considered inefficient compared to other DMUs (Avkiran, 2001).

To calculate efficiency scores, the DEA model employs three optimization approaches: 1) Constant Returns to Scale (CRS); 2) Variable Returns to Scale (VRS); and 3) Scale Efficiency (SE). The CRS model, also known as the CCR model by Charnes, Cooper, and Rhodes (1978), assumes that input and output increases are proportional. This means that if inputs increase by a factor of  $x$ , outputs will also increase by the same factor, assuming optimal scale. The VRS model, also known as the BCC model by Banker, Charnes, and Cooper (1984), allows for variable input-output ratios, meaning an input increase by a factor of  $x$  could result in a larger or smaller output increase. The SE model combines both CRS and VRS models, distinguishing between them.

This study uses the SE model, which assumes that the CRS efficiency score reflects technical efficiency, measuring inefficiency due to input-output configuration and operational size. In contrast, the VRS efficiency score reflects pure technical efficiency, excluding scale efficiency. The SE model helps to compare CRS and VRS efficiency scores to identify changes in scale efficiency based on inputs and outputs (Avkiran, 2001). This input-oriented model assumes that maximizing output with a fixed amount of input measures the proportional reduction in input while maintaining a constant output.

However, the use of the DEA model has limitations in data interpretation, such as not providing analyses to help users determine whether the chosen model is appropriate, unlike statistical methods, additionally, the selection of input and output variables is based solely on user subjectivity (Smith, 1997). The DEA model only evaluates the efficiency of input and output variables without explaining the relationships between the variables (Bowlin, 2014). Furthermore, the DEA model is sensitive to data issues, such as uncertainty and accuracy (Lertworasirikul et al., 2003). Nevertheless, Arabmaldar et al. (Arabmaldar et al., 2017) stated that the DEA approach with robust optimization can address data uncertainty.

Table 1 below is a table that explains the Operational Definition of Healthcare Expenditure Efficiency Variable.

Table 1. Operational Definition of Healthcare Expenditure Efficiency Variable

| Input Variable  | Definition   | Measurement | Data Source & Reference   |
|---|--|-------------|---|
| Per Capita Healthcare Expenditure, PPP (current International \$) (HE)                      | Total healthcare expenditure divided by the population. This variable provides an overall depiction of the average healthcare expenditure per person.  | \$          | WDI (World Bank)<br>Ahmed et al. (2019)<br>Lionel (2015)<br>Liu et al. (2019) |
| Per Capita Domestic Government Healthcare Expenditure, PPP (current International \$) (GHE) | Total domestic income allocated for healthcare purposes and contributions from social insurance divided by the population. This represents public healthcare expenditure originating from domestic per capita sources. | \$          | WDI (World Bank)<br>Coccia (2021)<br>Vezhnovets et al. (2021)                 |
| Per Capita Out-of-Pocket Healthcare Expenditure, PPP (current International \$) (OOP)       | Total direct healthcare expenditure by households divided by the population. This variable describes direct healthcare spending from household pockets.  | \$          | WDI (World Bank)<br>Jakovljevic et al. (2020)                                 |

| Output Variable                                | Definition   | Measurement | Data Source & Reference   |
|--|--|-------------|---|
| Life Expectancy at Birth (total years) (LE)    | The number of years expected for a newborn baby to live if he/she were to experience the mortality rate at birth based on gender and age in a specific year, country, or region. | Year        | WDI (World Bank)<br>Ahmed et al. (2019)<br>Hsu (2014)<br>Lionel (2015)<br>Shi et al. (2022) |
| Infant Mortality Rate (per 1,000 births) (IMR) | The number of infants who die before reaching one year of age, per 1,000 live births in a specific year.   | People      | WDI (World Bank)<br>Ahmed et al. (2019)<br>Hsu (2014)<br>Lionel (2015)                      |

Source: Data processed (2023)

### 3. RESULTS AND DISCUSSION

#### DESCRIPTIVE STATISTICS OF HEALTHCARE EXPENDITURE EFFICIENCY

Based on the DEA analysis using DEAP 2.1 software application, here are the mean, standard deviation, minimum, and maximum values of healthcare expenditure efficiency in OIC countries over a 15-year period from 2004 to 2018. The Table 2 shows that the efficiency values of healthcare expenditure in OIC countries fluctuated between approximately 0.400 and 0.600 over the 19-year period. Overall, the efficiency values for the 50 OIC member countries from 2004 to 2018 averaged only 16.5 percent.

Table 2. Descriptive Statistics of Healthcare Expenditure Efficiency Variables

| Variables | N  | Mean  | Sd    | Min   | Max |
|-----------|----|-------|-------|-------|-----|
| y2004     | 50 | 0.626 | 0.327 | 0.510 | 1   |
| y2005     | 50 | 0.607 | 0.334 | 0.780 | 1   |
| y2006     | 50 | 0.543 | 0.316 | 0.850 | 1   |
| y2007     | 50 | 0.544 | 0.311 | 0.740 | 1   |
| y2008     | 50 | 0.542 | 0.315 | 0.100 | 1   |
| y2009     | 50 | 0.492 | 0.319 | 0.340 | 1   |
| y2010     | 50 | 0.550 | 0.335 | 0.170 | 1   |
| y2011     | 50 | 0.583 | 0.318 | 0.660 | 1   |
| y2012     | 50 | 0.594 | 0.335 | 0.500 | 1   |
| y2013     | 50 | 0.507 | 0.337 | 0.520 | 1   |
| y2014     | 50 | 0.483 | 0.344 | 0.440 | 1   |
| y2015     | 50 | 0.478 | 0.326 | 0.450 | 1   |
| y2016     | 50 | 0.625 | 0.323 | 0.115 | 1   |
| y2017     | 50 | 0.582 | 0.330 | 0.240 | 1   |
| y2018     | 50 | 0.504 | 0.317 | 0.710 | 1   |

Source: Data processed (2023)

#### YEARLY TRENDS IN HEALTHCARE EXPENDITURE EFFICIENCY

For a detailed analysis of healthcare expenditure efficiency in OIC countries during this period, Figure 1 presents the average efficiency results by year, Figure 2 shows the results by country and Table 3 shows frequency by countries of average healthcare expenditure efficiency. Based on Figure 1, the average value of healthcare expenditure efficiency during the period from 2004 to 2018 is 0.551 and fluctuates within the range from a minimum value of 0.478 to a maximum value of 0.627. The maximum value was reached in 2004, while the minimum value was observed in 2015. This average efficiency value indicates that healthcare expenditure management in OIC countries has not yet achieved optimal results, as the achieved efficiency values are still far from the efficient boundary of 1.



According to the SESRIC report (2019), in 2016, total healthcare expenditure in OIC countries was relatively low, allocating only 4.6 percent of total GDP, compared to three times the average of advanced countries at 12.8 percent and the global average at 11.8 percent. Meanwhile, the average healthcare expenditure per capita was \$161, compared to \$5,725 in advanced countries.

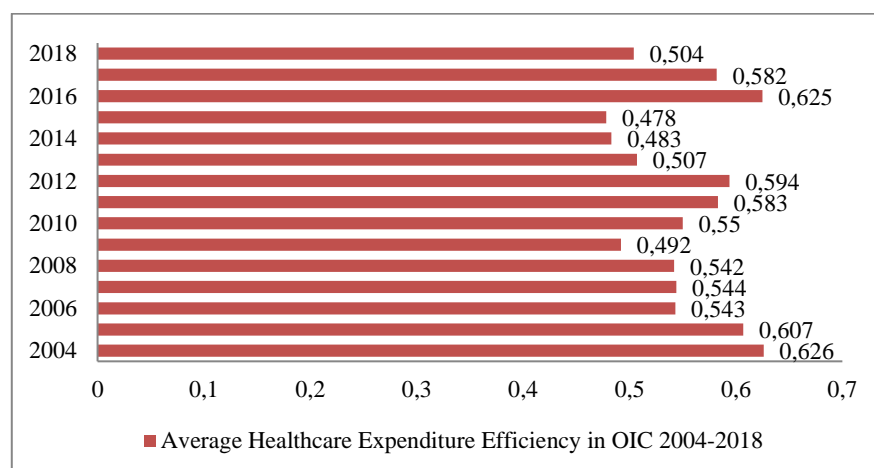


Figure 1. Average Healthcare Expenditure Efficiency Based on Year  
Source: Data processed (2023)

Government healthcare expenditure in OIC countries stood at 8.6 percent, significantly lower than the 26.1 percent observed in advanced countries. Conversely, out-of-pocket healthcare expenditure in OIC countries reached 37.8 percent, surpassing the figures for non-OIC developing countries (37.4 percent), advanced countries (13.5 percent), and the global average (18.6 percent). This high out-of-pocket spending is predominantly observed in developing countries, including many OIC member states categorized as Low Income Countries (LICs) and Lower Middle Income Countries (LMICs). Rahman et al. (2022) attribute this trend to inadequate financial risk protection and inconsistent health insurance coverage, resulting in limited access to comprehensive healthcare services.

Health outcomes, including life expectancy and infant mortality rates, are comparatively lower in OIC countries compared to non-OIC developing countries, advanced countries, and the global average. According to the SESRIC report (2019), average life expectancy in OIC countries increased from 62.6 to 68.6 years between the early 2000s and 2017. In contrast, non-OIC developing countries saw an increase from 65.8 to 71.7 years, advanced countries from 77.4 to 81.4 years, and globally from 67 to 72.5 years. Similarly, the average infant mortality rate per 1,000 live births decreased from 2000 to 2010, with OIC countries decreasing from 68 to 51 children, non-OIC developing countries from 50 to 35 children, and advanced countries showing very low rates of under-5 child deaths. Globally, the rate decreased from 51 to 37 children. Despite ranking lowest in health outcomes, there has been a significant decrease in infant and under-5 mortality rates from 1990 to 2017, attributed to improvements in healthcare systems and standards of living (SESRIC, 2019).

Based on Figure 2, it is shown that the average efficiency values of healthcare expenditure in OIC countries vary greatly, ranging from 0.1 to 0.9 over 15 years. This indicates that no OIC member country consistently falls into the efficient category in terms of average healthcare expenditure during the period from 2004 to 2018. The OIC member country with the most efficient average level is Qatar with an average value of 0.988. According to the SESRIC report (2013) one of the reasons for this is the significant decrease in out-of-pocket healthcare expenditure in the early 2000s until 2011, from 26.4 percent to 13.7 percent. In 2017, Qatar became one of the five OIC countries with the lowest out-of-pocket healthcare expenditure, below 15 percent, followed by Brunei Darussalam, Oman, Mozambique, and Suriname.

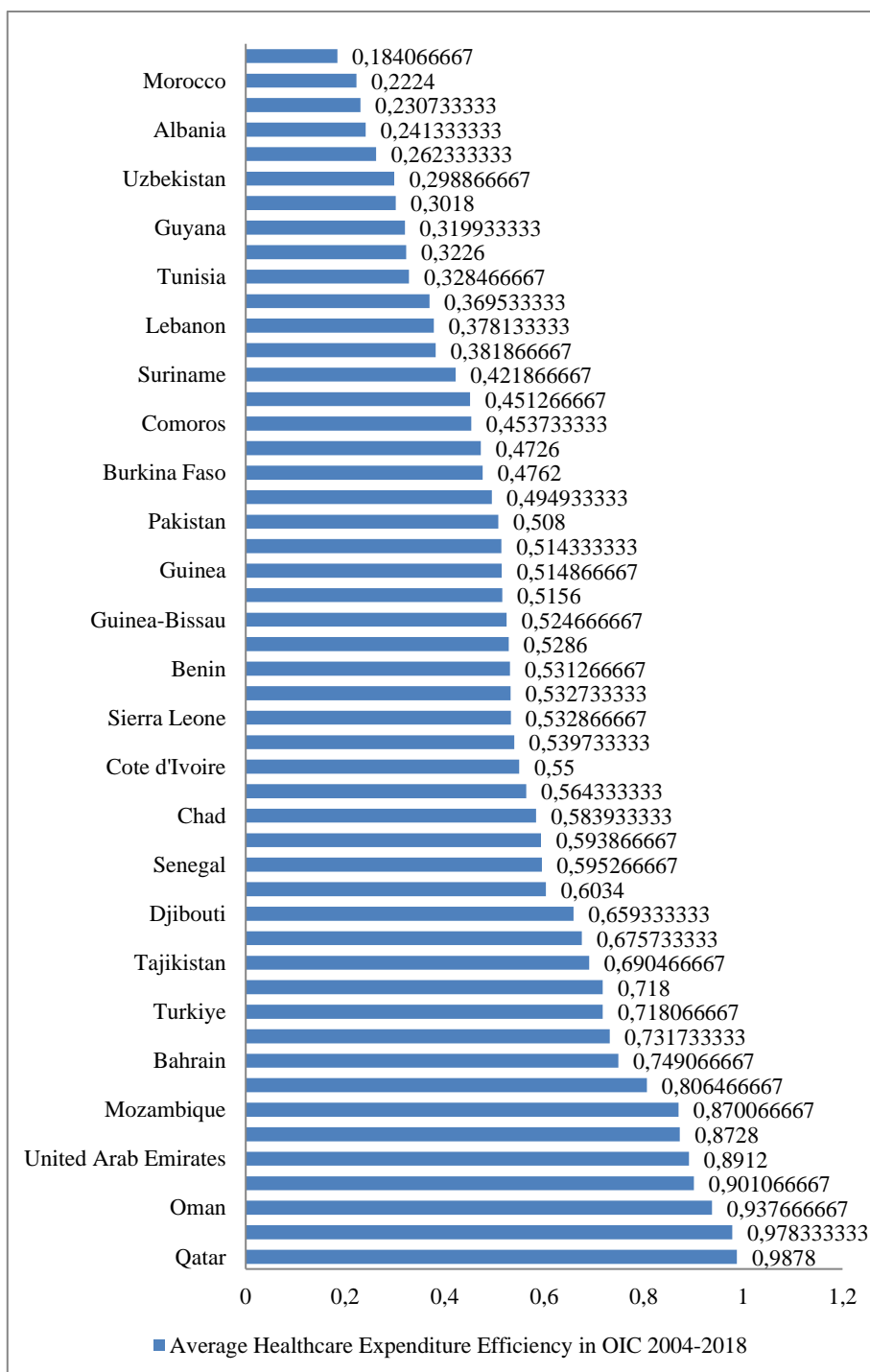


Figure 2. Average Efficiency of Healthcare Expenditure in OIC by Country  
Source: Data processed (2023)

This indicates that Qatar's healthcare expenditure is relatively good considering that out-of-pocket healthcare expenditure accounts for a significant portion of total healthcare expenditure, especially for developing countries, as is the case for many OIC countries. The implication is that high out-of-pocket healthcare expenditure in developing countries makes it increasingly difficult for the poor to access healthcare services, particularly for sudden care and examinations. As stated by Galárraga et al., (2010) out-of-pocket healthcare expenditure is the most inefficient healthcare payment method and exacerbates inequality in funding healthcare.

Another point emphasized by Barkat et al. (2019) is that healthcare in Gulf countries, including Qatar, is considered a primary necessity rather than a luxury item. Moreover, with the increasing expatriate population in these countries, there is greater emphasis on the healthcare sector. This is evident in the requirement for comprehensive health tests for expatriates and students entering these countries, as well as mandatory annual check-ups for residents. Additionally, Ali et al. (2015) suggest that reducing copayments in Qatar's healthcare insurance system can enhance satisfaction with healthcare services, aligning with the finding that Qatar demonstrates efficient management of healthcare expenditure. The average frequency of efficiency values ranging from 0.100 to 0.900 can be seen in table 3 below.

Table 3. Frequency of Average Healthcare Expenditure Efficiency

| Frequency of Efficiency Value | Number | Country   |
|-------------------------------|--------|---|
| 0.900-0.999                   | 4      | Brunei Darussalam, Kuwait, Oman and Qatar   |
| 0.800-0.899                   | 4      | Gambia, Mozambique, Saudi Arabia and UEA  |
| 0.700-0.799                   | 4      | Bahrain, Nigeria, Turkiye and Uganda  |
| 0.600-0.699                   | 4      | Djibouti, Mali, Sudan and Tajikistan  |
| 0.500-0.599                   | 15     | Bangladesh, Benin, Cameroon, Chad, Cote d'Ivoire, Guinea, Guinea Bisau, Indonesia, Maldives, Mauritania, Niger, Pakistan, Siere Leone, Senegal and Togo |
| 0.400-0.499                   | 6      | Algeria, Burkina Faso, Comoros, Jordan, Kazakhastan and Suriname  |
| 0.300-0.399                   | 7      | Azerbaijan, Guyana, Iran, Kyrgyz, Lebanon, Malaysia, and Tunisia  |
| 0.200-0.299                   | 5      | Albania, Gabon, Marocco, Turkmenistan and Uzbekistan  |
| 0.100-0.199                   | 1      | Egypt   |

Source: Data processed (2023)

From the data above, it can be observed that the highest values approaching efficiency are seen in OIC member countries such as Qatar, Brunei Darussalam, Oman, Kuwait, followed by the UAE and Saudi Arabia. According to the SESRIC report (SESRIC, 2019), the majority of the highest average efficiency values come from the MENA region, with Qatar leading in healthcare expenditure per capita at \$1827.1, followed by the UAE and Saudi Arabia. Similarly, out-of-pocket healthcare expenditure below 15 percent is observed in countries like Brunei Darussalam, Oman, Qatar, and Saudi Arabia. These findings are supported by research by Azeez et al. (2017) based on the World Bank report (2015), which categorized the UAE, Saudi Arabia, Oman, Qatar, and Brunei Darussalam as High Income countries.

Egypt has the lowest average efficiency score at 0.183, which is attributed to several factors outlined in the SESRIC report (2013). The report highlights the Egyptian Health Reform Program initiated in 1998, which aimed to enhance the health of the poor through various policies. Despite increased investment in healthcare infrastructure facilities, up to 40 percent of these facilities remained non-operational due to cost and registration service issues. The program was discontinued in 2007, partly due to poor government governance, including changes in government, political instability, and inadequate quality of public services in policy formulation and implementation. Another factor contributing to Egypt's low healthcare expenditure efficiency, is the high level of catastrophic healthcare expenditure incurred out of pocket in rural areas. This has led to increased poverty levels in poor households.

In general, several experts have identified factors that influence the fluctuations in the efficiency of healthcare spending in a country based on input and output mechanisms. The study by Fonchamnyo & Sama (2016) conducted in CEMAC countries stated that economic growth, broad money, and financial management contribute to improving the efficiency of healthcare spending, while inflation and corruption reduce the efficiency of healthcare spending.



Price et al. (2008), in their study, added that there is a mutually beneficial relationship between efficiency in healthcare spending, health outcomes, and improved economic performance, based on the possibility of effective control over lifestyle and environmental factors such as smoking, alcohol consumption, and maintaining a healthy diet in OECD countries. There is a rather unique fact observed in African countries, where the variable of colonial heritage can enhance government spending efficiency, with healthcare being one of the indicators, according to Adegboye & Akinyele (2022). This is assumed to result from the neutralization of the public sector administrative bureaucracy system in terms of public services, education, judicial systems, financial institutions, and others. Therefore, it is important to apply efficiency in the use of health expenditures in various countries, especially OIC countries, as it is related to various aspects such as economic growth, government effectiveness, and health status.

#### 4. CONCLUSION

Among the input variables used were healthcare expenditure per capita, PPP (current international \$), domestic government healthcare expenditure per capita, PPP (current international \$), and out-of-pocket healthcare expenditure per capita, PPP (current international \$). Meanwhile, the output variables used health indicators in the form of life expectancy at birth (total years) and infant mortality rate (per 1,000 live births). The results of this study indicate that the average efficiency score of OIC countries from 2004 to 2018 was 0.551. The countries with the highest efficiency scores were predominantly Middle Eastern countries, including Qatar with the highest efficiency score followed by, Oman, Kuwait, UAE, and Saudi Arabia, as well as Brunei Darussalam while the lowest efficiency score was found in Egypt.

The implications of this research on healthcare expenditure efficiency, both academically and practically, are significant. Firstly, there is a need for equalization through government-managed insurance policies to alleviate the burden of out-of-pocket healthcare expenditure, particularly for the economically disadvantaged. Secondly, the allocation of government healthcare funds should be based on various influencing factors such as political, economic, demographic, and geographic stability to ensure equitable distribution. Thirdly, policies aimed at reducing stunting rates and ensuring the health of pregnant women are crucial. Lastly, public awareness campaigns about the importance of investing in the healthcare sector are essential.

However, the study has certain limitations. It primarily relies on macro-level aggregate data, and future research could benefit from incorporating micro-level survey data from each of OIC member countries. The study period 2004 to 2018 may limit its relevance, especially considering the global impact of the Covid-19 pandemic from late 2019 onwards. Future research should explore out-of-pocket healthcare expenditure both pre- and post-pandemic to inform more effective healthcare policies and strategies. In addition, the use of DEA based on robust optimization is more feasible for obtaining more optimal results in addressing abnormal data uncertainty.

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