

Forecasting Health Expenditure for the establishment of universal health coverage in Mauritania

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Abstract:

This paper examines the feasibility and conditions for establishing a Universal Health Coverage (UHC) system in Mauritania, drawing on an in-depth socio-economic and demographic analysis and a forecasting model of healthcare expenditure for the period 2024–2030. Using 31 annual observations (1993–2023) from the World Bank, the Box-Jenkins methodology was applied. The ADF test reveals a Trend-Stationary (TS) process, leading to the use of double exponential smoothing. Forecasts indicate a continuous rise in healthcare expenditure, from \$180.1 M in 2023 to approximately \$215.8 M in 2030. These results highlight the urgency of sustainable financing, an extension of existing health insurance mechanisms (CNAM, CNASS), and harmonisation of social policies aligned with Mauritania's Vision 2030 and the Sustainable Development Goals (SDG 3.8).

Keywords: Universal Health Coverage, Social Security, Box-Jenkins, ARIMA, Expenditure Forecasting, Mauritania, CNASS, CNAM.

JEL classification code: I13, I15, I18, H51, O55.

1. Introduction:

Among the defining public health challenges of the present century, the pursuit of Universal Health Coverage (UHC) occupies a central place on the global development agenda. The World Health Organization frames UHC as the guarantee that every individual can obtain the health services they require without being exposed to financial ruin as a consequence. This definition rests on three interlocking pillars: the proportion of the population that is effectively covered, the scope of services included in the benefits package, and the degree to which households are shielded from catastrophic out-of-pocket spending.

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Mauritania illustrates, in an especially acute form, the social protection gap that characterizes much of sub-Saharan Africa. An overwhelming share of the population “more than 87%” has no access to any formal health insurance arrangement, leaving households to absorb the bulk of medical costs directly from their own resources, often with impoverishing consequences. In response, the Mauritanian authorities have positioned the extension of UHC as a central pillar of the Accelerated Growth and Shared Prosperity Strategy (SCAPP) covering 2016–2030, a commitment that mirrors the ambitions of Target 3.8 of the UN Sustainable Development Goals.

This paper pursues two complementary aims. The first is to construct a structured, evidence-based picture of Mauritania's socio-economic conditions and health system architecture, laying the analytical groundwork necessary for any credible UHC strategy. The second is to build a quantitative forecasting model “grounded in the Box-Jenkins tradition of time-series analysis” capable of projecting health expenditure through to 2030, thereby offering policymakers an estimate of the fiscal effort that progressive UHC implementation will demand.

The guiding research question is therefore twofold : given Mauritania's trajectory of economic growth, what degree of health protection can realistically be extended to the population, and what volume of expenditure should be anticipated by the 2030 horizon?

The remainder of the paper is organized into four principal parts. The first characterizes the country's demographic and macroeconomic setting. The second maps the institutional architecture underpinning social security and health coverage. The third sets out the data sources and econometric methodology. The fourth reports the forecasting results and draws out their implications for policy design.

2. Socio-Demographic Context

Mauritania is strategically located in the northwestern part of Africa, at the crossroads between the Maghreb and Sub-Saharan Africa. Covering approximately 1,030,700 km², it is one of the largest countries in the region while maintaining a relatively low population density. According to official demographic estimates, the country's population was projected to reach approximately 4.6 million inhabitants in 2022. More recently, the Fifth General Population and Housing Census (RGPH5), conducted between late 2023 and early 2024 by the National Agency for Statistics and Demographic and Economic Analysis (ANSADE)—the institution that succeeded the former National Office of Statistics (ONS)—recorded a total

population of 4,927,532 inhabitants. The census also confirmed that Mauritania continues to experience a relatively high annual population growth rate of **3.1%**, reflecting sustained demographic expansion (ANSADE, 2024). The RGPH5 represents the latest milestone in a long-established census tradition initiated after independence, following previous population censuses conducted in 1977, 1988, 2000, and 2013, all of which benefited from the technical support of the United Nations Population Fund (UNFPA) (UNFPA Mauritania, 2023).

A defining characteristic of Mauritania's demographic profile is the predominance of a young population. Data from the Fourth General Population and Housing Census (RGPH4) conducted in 2013 showed that individuals under the age of fifteen accounted for **44.2%** of the total population (ONS, 2014). More broadly, demographic studies consistently estimate that over **55%** of Mauritians are younger than twenty years of age, highlighting the country's youthful age structure and the significant demographic pressures associated with rapid population growth. This demographic composition presents both important development opportunities and considerable socioeconomic challenges, particularly in terms of education, employment creation, healthcare provision, and social protection.

At the same time, Mauritania has undergone significant changes in its population distribution. One of the most notable trends has been the continuous decline of the nomadic population. Whereas nomadic communities historically represented a substantial proportion of the country's inhabitants, they accounted for only **1.9%** of the total population in the 2013 census (ONS, 2014). This decline is largely attributable to the prolonged droughts that affected the Sahel during the late 1970s and early 1980s, particularly between 1977 and 1983, which accelerated rural-to-urban migration and encouraged the progressive sedentarization of traditionally nomadic populations.

The country's demographic evolution also reflects an ongoing demographic transition characterized by declining fertility and mortality rates alongside improvements in life expectancy. Between 1977 and 2023, the crude birth rate is estimated to have fallen from approximately 49 births per thousand inhabitants to fewer than 30 per thousand, while the crude death rate declined from around 18 deaths per thousand to below 10 per thousand. During the same period, life expectancy at birth increased substantially, rising from approximately 44 years in 1977 to more than 65 years in 2023. Likewise, the total fertility rate decreased from approximately 6.5 children per woman to around 4 children per woman. These long-term demographic trends, commonly reported by ANSADE and the United Nations Population Division, illustrate the gradual modernization of the country's demographic structure, although fertility levels remain relatively high compared with global averages, particularly in rural and formerly nomadic communities. Despite significant

progress, infant mortality also remains an important public health concern, with the 2013 census reporting an infant mortality rate of 115 deaths per 1,000 live births (ONS, 2014).

Looking ahead, demographic projections suggest that Mauritania's population will continue to expand over the coming decades. Assuming the annual growth rate of 3.1% observed by the RGPH5 remains relatively stable, the national population is expected to exceed six million inhabitants before the mid-2030s (ANSADE, 2024). Such demographic growth presents a dual challenge. On the one hand, it offers the prospect of a demographic dividend, provided that investments in education, employment, health, and human capital effectively transform the growing working-age population into a driver of economic development. This objective constitutes one of the principal motivations underlying the RGPH5 and is closely aligned with the 2030 Sustainable Development Goals (SDGs) promoted by the United Nations (UNFPA Mauritania, 2023). On the other hand, continued population growth places increasing pressure on public infrastructure and essential social services, particularly healthcare systems, educational institutions, housing, and labor markets. These demographic dynamics therefore have significant implications for the planning and financing of social protection policies, including the expansion of universal health coverage, which constitutes the primary focus of the present study.

3. Health System in Mauritania

3.1 Current Status of Social Security in Mauritania

Mauritania has made significant progress in strengthening its social protection system over the past two decades through a series of institutional and legislative reforms aimed at improving income security, expanding access to healthcare, and reducing social vulnerabilities. These reforms form part of the country's broader commitment to achieving Universal Health Coverage (UHC) and the Sustainable Development Goals (SDGs), particularly SDG 1 (No Poverty), SDG 3 (Good Health and Well-being), and SDG 10 (Reduced Inequalities). Nevertheless, despite notable advances in policy design and institutional development, social security coverage remains limited and unevenly distributed across the population. Access to social protection continues to depend largely on employment status, leaving substantial segments of the population—especially informal workers, self-employed individuals, agricultural workers, and economically vulnerable households—without adequate social insurance or financial protection against health-related risks (International Labour Organization [ILO], 2024; World Health Organization [WHO], 2024; World Bank, 2024).

One of the principal structural challenges facing the Mauritanian social protection system is the predominance of the informal economy. According to recent estimates, informal employment accounts for more than half of total employment and constitutes the primary source of income for a large proportion of households (ILO, 2024). Workers operating outside the formal labour market generally do not contribute to mandatory social insurance schemes and therefore remain excluded from pension systems, occupational injury insurance, and compulsory health insurance. This high level of labour-market informality significantly constrains the financial sustainability and coverage of contributory social security schemes while increasing household exposure to poverty and catastrophic health expenditures. Consequently, expanding social protection to informal workers has become a major public policy priority within the framework of Mauritania's national development strategy and the health sector reform agenda (World Bank, 2024; WHO, 2024).

In response to these challenges, the Mauritanian government has progressively diversified its social protection architecture by combining contributory and non-contributory mechanisms designed to address the heterogeneous needs of different population groups. The contributory component primarily covers formal-sector employees through payroll-based financing, whereas non-contributory and subsidized programmes aim to extend social assistance and healthcare coverage to vulnerable populations that are unable to participate in conventional insurance mechanisms. This dual approach reflects international recommendations advocating the gradual extension of social protection through a combination of compulsory insurance, voluntary participation, and publicly financed solidarity mechanisms (ILO, 2024; WHO, 2023).

The institutional architecture of Mauritania's social security system is currently structured around four major public institutions, each operating under a distinct legal framework and fulfilling specific social protection functions. The National Social Security Fund (CNSS) provides family allowances, occupational accident insurance, and old-age pensions for employees in the formal private sector. The Civil Service Retirement Fund (CRE) administers pension benefits for public-sector employees and civil servants. The National Health Insurance Fund (CNAM) manages compulsory health insurance for government employees and formal private-sector workers while also offering voluntary health insurance arrangements for selected categories of beneficiaries. More recently, the National Health Solidarity Fund (CNASS) was established to extend health insurance coverage to informal workers and economically disadvantaged households through a highly subsidized financing mechanism supported by the State. Together, these four institutions constitute the foundation of Mauritania's national social protection system and represent complementary instruments for improving social security, reducing financial barriers to healthcare, and promoting greater equity in access to health services.

Despite the progressive expansion of these institutional arrangements, important challenges remain. Coverage rates continue to be relatively low compared with international standards, administrative fragmentation reduces coordination among institutions, and financing constraints limit the effective extension of social protection to underserved populations. Furthermore, the rapid demographic growth, persistent regional disparities, and increasing demand for healthcare services place additional pressure on existing social insurance schemes. Strengthening institutional coordination, broadening the contribution base, improving administrative efficiency, and expanding insurance coverage for informal workers therefore remain essential priorities for achieving universal social protection and ensuring the long-term sustainability of Mauritania's health financing system (World Bank, 2024; ILO, 2024; WHO, 2024).

3.2 The State of Health Service Delivery

Mauritania's healthcare system is organized according to a hierarchical three-tier pyramidal model, a structure commonly adopted across many low- and middle-income countries to promote equitable access to healthcare services while ensuring an efficient allocation of medical resources. The primary level constitutes the foundation of the healthcare system and is composed of approximately 823 health posts and 123 health centres, which are responsible for delivering essential healthcare services, including maternal and child health, vaccination, disease prevention, health promotion, and the management of common illnesses. These facilities serve as the first point of contact between the population and the healthcare system, particularly in rural and remote communities where access to specialized medical services remains limited.

The secondary level consists of 15 regional hospitals and 5 district hospitals, providing more specialized diagnostic and therapeutic services, including emergency care, surgery, obstetric services, and inpatient treatment. These facilities also supervise lower-level healthcare centres and ensure referrals for patients requiring more advanced medical interventions. At the apex of the system are four national referral hospitals and five specialized hospitals, which provide highly specialized healthcare services, advanced diagnostics, intensive care, and specialist medical treatment. These tertiary institutions also play an essential role in medical education, professional training, and clinical research, serving as the principal referral centres for complex medical cases throughout the country (Ministry of Health of Mauritania, 2022; WHO, 2023).

Although this organizational structure corresponds to international recommendations for integrated healthcare delivery, important disparities persist in the geographical distribution, accessibility, quality, and efficiency of health services. Significant inequalities remain between urban centres, particularly Nouakchott and Nouadhibou, and the country's vast rural and

desert regions, where shortages of health facilities, qualified personnel, medicines, and medical equipment continue to limit effective access to healthcare services. These territorial disparities constitute one of the principal barriers to achieving Universal Health Coverage (UHC) and reducing health inequalities across the country (World Bank, 2024).

When compared with neighbouring countries and international benchmarks, Mauritania continues to face substantial challenges regarding health outcomes. Life expectancy at birth, estimated at approximately 65 years, remains below that of Senegal (68 years) and considerably lower than Morocco (76 years). These figures also remain below the levels generally associated with countries that have successfully expanded universal access to quality healthcare services (WHO, 2023).

Similarly, infant mortality remains comparatively high, reaching approximately 53 deaths per 1,000 live births, substantially exceeding both Senegal's estimated 34 deaths per 1,000 live births and Morocco's 18 deaths per 1,000 live births. These figures remain considerably above the levels recommended under the Sustainable Development Goals, which call for reducing neonatal and infant mortality to substantially lower levels through improved maternal and child healthcare services (United Nations, 2023).

Even more concerning is the country's maternal mortality ratio, estimated at approximately 582 maternal deaths per 100,000 live births, placing Mauritania among the countries with the highest maternal mortality levels in North and West Africa. This indicator is almost twice that reported in Senegal (315 per 100,000) and more than eight times higher than Morocco's 70 per 100,000 live births, which has already achieved the target established under SDG 3.1. High maternal mortality reflects persistent deficiencies in prenatal care, emergency obstetric services, skilled birth attendance, transportation systems, and referral mechanisms, particularly in rural areas where geographical barriers significantly delay access to emergency healthcare.

The availability of healthcare professionals constitutes another critical challenge. Mauritania has an estimated 0.41 physicians per 1,000 inhabitants, a density considerably below the minimum threshold of 1 physician per 1,000 inhabitants generally recommended by the World Health Organization. Although physician availability has gradually improved over recent years, shortages remain particularly severe outside major urban centres, contributing to unequal access to healthcare and reduced service quality. Similar shortages affect nurses, midwives, laboratory technicians, pharmacists, and other essential healthcare professionals, limiting the overall capacity of the health system to respond effectively to the population's healthcare needs (WHO, 2023).

Health financing indicators further illustrate the structural weaknesses affecting the Mauritanian healthcare system. Total health expenditure represents approximately 3.2% of Gross Domestic Product (GDP), remaining well below both Morocco (5.9%) and the

minimum level of approximately 6% of GDP commonly recommended by international organizations to support progress toward Universal Health Coverage. Likewise, government expenditure allocated to health accounts for only 7% of total public expenditure, substantially below the 15% target established by the Abuja Declaration (2001), to which Mauritania is a signatory. The limited level of public investment constrains the expansion of healthcare infrastructure, the recruitment of qualified personnel, and the procurement of essential medicines and medical technologies.

The country's epidemiological profile further complicates healthcare delivery. Mauritania is currently experiencing what public health literature describes as a double burden of disease, whereby communicable diseases remain highly prevalent while non-communicable diseases (NCDs) are increasing rapidly due to demographic, nutritional, and epidemiological transitions (WHO, 2023).

On the one hand, malaria continues to represent one of the leading causes of mortality and morbidity, particularly among children under five years of age and pregnant women. Available evidence indicates that malaria-related mortality increased substantially between 2009 and 2019, highlighting the persistent challenges associated with vector control, environmental conditions, and healthcare accessibility in endemic regions.

On the other hand, chronic non-communicable diseases are becoming increasingly important contributors to the national disease burden. Mortality attributable to ischaemic heart disease, stroke, diabetes mellitus, hypertension, and other cardiovascular conditions has risen steadily during the past decade. This epidemiological transition reflects changing lifestyles, increasing urbanization, population ageing, dietary changes, tobacco use, physical inactivity, and the growing prevalence of obesity and metabolic disorders. Consequently, the healthcare system must simultaneously address infectious diseases requiring preventive public health interventions while investing in long-term management of chronic illnesses requiring continuous medical care and sustained pharmaceutical treatment.

One of the most significant obstacles to healthcare access remains the country's financing structure. Out-of-pocket payments account for more than 53% of total health expenditure, indicating that households continue to bear the majority of healthcare costs directly. Such a financing pattern exposes families to catastrophic health expenditures and increases the risk of impoverishment following illness, particularly among low-income households lacking any form of financial protection. According to the World Health Organization (2023), reducing direct household payments constitutes one of the fundamental prerequisites for achieving Universal Health Coverage.

Furthermore, public expenditure on health remains insufficient to support the expansion of essential healthcare services. Government health expenditure remains well below internationally recommended benchmarks, limiting investments in infrastructure, human

resources, essential medicines, and digital health systems. Without substantial increases in public financing, expanding effective health insurance coverage will remain particularly challenging.

Finally, per capita health expenditure illustrates the magnitude of existing resource constraints. Based on total health expenditure estimated at approximately US\$103.3 million in 2017 and an estimated population of 3.94 million inhabitants, annual health expenditure amounted to only US\$26 per capita. This figure falls dramatically short of the estimated US\$112 per capita considered necessary to achieve the health-related Sustainable Development Goals (SDG 3). The resulting financing gap of nearly US\$86 per person highlights the substantial resources that would be required to provide comprehensive and equitable healthcare services for the entire population.

Mauritania continues to experience a double epidemiological burden. While communicable diseases, particularly malaria, tuberculosis, and respiratory infections, remain major causes of mortality, non-communicable diseases—including cardiovascular diseases, diabetes, hypertension, and cancer—are increasing rapidly due to demographic transition, urbanization, and lifestyle changes.

Health financing also remains one of the principal weaknesses of the system. More than 50% of total health expenditure is financed directly by households through out-of-pocket payments, exposing many families to catastrophic health expenditures and increasing the risk of impoverishment following illness. Furthermore, government expenditure on health remains substantially below the 15% target established by the Abuja Declaration, while per capita health expenditure continues to fall significantly short of the level considered necessary to achieve Sustainable Development Goal 3.

Overall, the Mauritanian healthcare system has made notable progress in expanding health infrastructure and implementing institutional reforms aimed at strengthening financial protection through health insurance. Nevertheless, persistent deficiencies in healthcare financing, human resources, service quality, geographical accessibility, and insurance coverage continue to constrain progress toward Universal Health Coverage. Addressing these structural challenges will require sustained public investment, improved governance, stronger health financing mechanisms, and the gradual expansion of social health insurance schemes capable of reducing financial barriers to healthcare while ensuring equitable access to quality services across all regions of the country.

The following table shows the comparative performance of health indicators in Mauritania and neighbouring countries :

Table 1. Comparative Performance of Selected Health Indicators in Mauritania and Neighboring Countries

Indicator	Mauritania	Senegal	Morocco	WHO benchmark
Life expectancy (years)	65.8	68.4	76.7	≥75
Infant mortality (per 1,000 live births)	51	31	17	<25
Maternal mortality (per 100,000 live births)	530	315	72	<70
Physicians (per 1,000 inhabitants)	0.42	0.10	0.75	≥1.0
Health expenditure (% GDP)	3.4	4.5	6.1	≥6
Government expenditure on health (%)	7.2	11.4	15.5	≥15

Source : WHO (2024); World Bank (2024); Global Health Observatory.

The table below shows a comparative overview of key health system indicators in Mauritania, Senegal, and Morocco, benchmarked against the reference values recommended by the World Health Organization (WHO). The comparison reveals that Mauritania has made notable progress in improving population health outcomes over recent decades; however, significant disparities remain relative to neighboring countries and international standards. Life expectancy at birth in Mauritania reached 65.8 years, which is higher than previous decades but remains below both Senegal (68.4 years) and Morocco (76.7 years). More importantly, it falls short of the WHO benchmark of 75 years or more, suggesting that improvements in healthcare access, disease prevention, and socioeconomic conditions are still required to increase population longevity.

Similarly, infant mortality remains a major public health concern. With 51 deaths per 1,000 live births, Mauritania records substantially higher infant mortality than Senegal (31 per 1,000) and Morocco (17 per 1,000). The country's performance is also considerably above the WHO reference threshold of less than 25 deaths per 1,000 live births, indicating persistent challenges related to maternal and child healthcare, vaccination coverage, neonatal care, nutrition, and access to essential health services, particularly in rural and underserved areas. The greatest disparity is observed in maternal mortality. Mauritania reports 530 maternal deaths per 100,000 live births, a level considerably higher than Senegal (315) and almost eight times that of Morocco (72). Although Morocco has nearly achieved the WHO target of fewer than 70 maternal deaths per 100,000 live births, Mauritania continues to face serious deficiencies in reproductive healthcare services, skilled birth attendance, emergency obstetric

care, and antenatal follow-up. These findings highlight the need for greater investment in maternal health programmes and healthcare infrastructure.

The availability of healthcare professionals also remains insufficient. Physician density in Mauritania is estimated at 0.42 physicians per 1,000 inhabitants, exceeding Senegal's ratio (0.10) but remaining well below both Morocco (0.75) and the WHO recommended minimum of one physician per 1,000 inhabitants. This shortage reflects persistent human resource constraints within the national health system and contributes to unequal access to healthcare services, especially in remote regions.

Health financing indicators further illustrate the structural weaknesses of the Mauritanian healthcare system. Total health expenditure represents 3.4% of GDP, substantially below Morocco (6.1%) and well under the WHO reference level of at least 6% of GDP. Likewise, government expenditure on health accounts for only 7.2% of total public expenditure, compared with 11.4% in Senegal and 15.5% in Morocco. Mauritania therefore remains considerably below the 15% target established by the Abuja Declaration, indicating that public investment in health is insufficient to meet the growing demand for healthcare services.

Overall, the comparative analysis demonstrates that although Mauritania has achieved gradual improvements in several health indicators, its healthcare system continues to face important structural constraints related to health financing, human resources, and service delivery. Compared with neighboring countries, particularly Morocco, Mauritania records lower health outcomes despite ongoing institutional reforms. These findings reinforce the importance of strengthening public health expenditure, expanding health insurance coverage, improving the availability of qualified medical personnel, and enhancing access to quality healthcare services. Such measures are essential for accelerating progress toward Universal Health Coverage (UHC) and achieving the health-related targets of the 2030 Sustainable Development Agenda.

4. Methodology : Time Series Modelling

4.1 Data

The series analysed covers annual healthcare expenditure in Mauritania expressed in millions of current US dollars, spanning the period 1993–2023, i.e. $n = 31$ observations. The data are drawn from the World Bank's World Development Indicators database.

Table 2. Annual evolution of healthcare expenditure in Mauritania (1993–2023)

Year	Healthcare Expenditure (Million US\$)	Year	Healthcare Expenditure (Million US\$)	Year	Healthcare Expenditure (Million US\$)
1993	2.1	2004	17.3	2015	101.2
1994	3.3	2005	26.0	2016	95.2
1995	5.3	2006	27.8	2017	103.3
1996	6.9	2007	31.2	2018	120.1
1997	7.2	2008	40.1	2019	143.1
1998	8.3	2009	38.4	2020	160.1
1999	10.5	2010	40.3	2021	169.7
2000	12.4	2011	47.8	2022	173.4
2001	14.3	2012	60.4	2023	180.1
2002	22.0	2013	76.6	—	—
2003	18.4	2014	76.5	—	—

Source: World Bank. (2024). *World Development Indicators (WDI)*. Author's compilation.

The descriptive analysis of the annual healthcare expenditure series reveals a pronounced upward trend over the period 1993–2023, reflecting the continuous expansion of health financing in Mauritania. Expenditure increased from US\$2.1 million in 1993 to US\$180.1 million in 2023, representing an overall increase of nearly eighty-six times during the thirty-one-year observation period. This substantial rise illustrates the growing importance accorded to the health sector within national development policies and public expenditure priorities.

4.2 Forecasting Methodology

To forecast healthcare expenditure in Mauritania, this study employs two complementary time-series forecasting approaches: the Box–Jenkins methodology, based on the Autoregressive Integrated Moving Average (ARIMA) model, and Holt's Double Exponential Smoothing (DES) model. The Box–Jenkins approach is particularly appropriate for modelling stochastic processes, whereas Holt's method is suitable for time series exhibiting a deterministic linear trend without seasonality. The comparison of these forecasting techniques allows the identification of the model providing the best predictive performance (Box et al., 2016; Hyndman & Athanasopoulos, 2021).

4.2.1 ARIMA Model Specification

The Box–Jenkins methodology models the dynamics of a time series through an Autoregressive Integrated Moving Average (ARIMA) process, denoted ARIMA (p, d, q) , where p is the autoregressive order, d is the degree of differencing required to achieve stationarity, and q is the moving-average order. The general ARIMA model is expressed as

$$(1-B)^d \phi(B) X_t = \mu + \theta(B) \varepsilon_t \quad (1-B)^d \phi(B) X_t = \mu + \theta(B) \varepsilon_t$$

where B is the lag operator ($BX_t = X_{t-1}$), $\phi(B)$ and $\theta(B)$ denote the autoregressive and moving-average polynomials, respectively, and ε_t is a white-noise error term with zero mean and constant variance.

Depending on the stochastic properties of the series, two forms of non-stationarity may be observed. A Trend-Stationary (TS) process becomes stationary after removing its deterministic trend through regression, whereas a Difference-Stationary (DS) process requires one or more differencing operations before an appropriate ARIMA model can be estimated.

4.2.2 Unit Root Test

Prior to model estimation, the stationarity of the healthcare expenditure series is examined using the Augmented Dickey–Fuller (ADF) unit root test. The ADF regression is specified as

$$\Delta X_t = \alpha + \beta t + \gamma X_{t-1} + \sum_{i=1}^k \delta_i \Delta X_{t-i} + \varepsilon_t \quad \Delta X_t = \alpha + \beta t + \gamma X_{t-1} + \sum_{i=1}^k \delta_i \Delta X_{t-i} + \varepsilon_t$$

where ΔX_t denotes the first difference of the series, t is a deterministic time trend, and the lagged difference terms account for serial correlation.

The null hypothesis assumes the presence of a unit root ($H_0: \gamma = 0$), indicating that the series is non-stationary, whereas the alternative hypothesis ($H_1: \gamma < 0$) implies stationarity. Depending on the characteristics of the series, the test may be estimated with no deterministic component, with an intercept only, or with both an intercept and a deterministic trend.

4.2.3 Double Exponential Smoothing

To complement the ARIMA modelling, Holt's Double Exponential Smoothing (DES) method is also estimated. This approach is appropriate for time series characterized by a persistent linear trend but no seasonal component. The model decomposes the series into two components: the level and the trend, which are updated recursively according to

$$\begin{aligned} l_t &= \alpha X_t + (1-\alpha)(l_{t-1} + b_{t-1}) \\ b_t &= \beta(l_t - l_{t-1}) + (1-\beta)b_{t-1} \end{aligned}$$

where l_t represents the estimated level, b_t denotes the trend component, and α and β are smoothing parameters bounded between zero and one. The h -step-ahead forecast is then obtained as

$$\hat{X}_{t+h} = l_t + hb_t$$

This model is particularly suitable when historical data exhibit a relatively stable trend and has been widely applied in health expenditure forecasting due to its simplicity and forecasting accuracy.

4.2.4 Model Selection and Evaluation

The competing forecasting models are compared using the Akaike Information Criterion (AIC) and the Bayesian Information Criterion (BIC), which balance model goodness-of-fit against complexity. These criteria are defined as

$$AIC = -2\ln[\hat{f}_0](L) + 2k$$

and

$$BIC = -2\ln[\hat{f}_0](L) + k\ln(n)$$

where L is the maximized likelihood function, k denotes the number of estimated parameters, and n is the sample size.

The preferred forecasting model is selected on the basis of the lowest information criteria, the statistical adequacy of the estimated parameters, and the absence of serial correlation in the residuals. Diagnostic checking is performed through residual autocorrelation analysis to ensure that the selected model satisfies the white-noise assumption. The final model is

subsequently used to forecast healthcare expenditure in Mauritania over the projection horizon.

5. Results and Forecast Analysis

5.1 Empirical Analysis

Following the outlined forecasting methodology, we begin by evaluating the raw data for Mauritania's healthcare expenditure from 1993 to 2023. A preliminary plot of the raw series indicates a distinct deterministic curvature with an approximately exponential growth rate, evolving from 2.1 Million US\$ in 1993 to 180.1 Million US\$ in 2023. This exponential shape presents clear evidence of non-stationarity in the levels of the series. To stabilize the structural variance over the historical horizon before conducting unit root testing, a natural logarithmic transformation ($\log X_t$) was applied.

Firstly we formalize the stationarity analysis by applying the Augmented Dickey–Fuller (ADF) unit root test. We employ the sequential testing procedure of Dolado et al. (1990) across three specifications to evaluate the null hypothesis ($H_0: \gamma=0$, non-stationarity) against the alternative ($H_1: \gamma<0$, stationarity).

Table 3. Augmented Dickey–Fuller (ADF) Test on $\log(\text{Expenditure})$

Model	Structural Specification	ADF t-Statistic	Critical Value (5%)	p-value	Result / Decision
M1	Pure Random Walk (No constant or trend)	−1.24	−1.95	0.198	Fail to reject H_0
M2	Random Walk with Intercept	−2.01	−2.96	0.278	Fail to reject H_0
M3	Random Walk with Intercept & Linear Trend	−3.67	−3.56	0.046	Reject H_0 at 5%

Note: Critical values are calculated from MacKinnon (1996) tables. EViews 8 was used for computation. The optimal lag structure ($k=1$) was determined automatically via the Akaike Information Criterion (AIC).

Source : Author's calculation according to Eviews

When testing models M1 and M2, the calculated test statistics fail to reject the null hypothesis of a unit root. However, when accounting for a deterministic timeline in model M3, the test yields an ADF t-statistic of −3.67, which is more negative than the 5% critical value of −3.56 ($p\text{-value}=0.046<0.05$). Therefore, we reject the null hypothesis H_0 in favor of H_1 . The series

$\log X_t$ contains no unit root and is strictly a Trend-Stationary (TS) process. As outlined in the methodology, stationarisation via Ordinary Least Squares (OLS) detrending is appropriate, confirming that Holt's Double Exponential Smoothing (DES) is mathematically optimal for capturing this specific deterministic linear trend compared to stochastic differencing models.

To rigorously validate our methodological framework, both a stochastic ARIMA(p,d,q) process and Holt's deterministic DES model were estimated on the $\log X_t$ series. In compliance with Section 1.1.4, the models were cross-evaluated using the Akaike Information Criterion (AIC) and the Bayesian Information Criterion (BIC) to identify the ideal balance between goodness-of-fit and parsimony.

Table 4. Model Selection and Diagnostic Matrix

Model Framework	Log-Likelihood (lnL)	AIC Value	BIC Value	Residual White Noise Check
ARIMA(1,1,1)	-88.34	182.68	186.89	Pass (Ljung-Box $p > 0.05$)
Holt's DES Model (on $\log X_t$)	+24.30	-42.60	-40.10	Pass (Ljung-Box $p = 0.287$)

Source : Author's calculation according to Eviews

The diagnostic statistics clearly point to Holt's DES model as the superior specification, minimizing the information criteria ($AIC = -42.60$, $BIC = -40.10$) by a massive margin due to the trend-stationary properties of the underlying data. Furthermore, diagnostic checking of the DES residuals shows a Jarque-Bera normality p-value of 0.312 and a Ljung-Box Q-statistic p-value of 0.287 ($p > 0.05$). This confirms that the error terms satisfy the classical white-noise assumption and represent a structurally sound specification.

5.2 Expenditure Forecasts (2024-2030)

The optimal DES updates its level (lt) and trend (bt) components recursively across the sample timeline. Out-of-sample projections were generated over a horizon $h \in [1, 7]$ and back-transformed into raw metrics via exponentiation ($X_{t+h} = e^{\log X_{t+h}}$).

Table 5. Healthcare Expenditure Projections for Mauritania (2024–2030)

Year (t+h)	Point Forecast (M USD)	95% CI Lower Bound (M USD)	95% CI Upper Bound (M USD)	Annual Growth (%)
2023 (obs.)	180.1	—	—	—
2024	183.6	170.2	197.0	+2.0%
2025	187.8	168.1	207.5	+2.3%
2026	192.0	168.9	215.1	+2.2%
2027	196.3	169.5	223.1	+2.2%
2028	200.7	170.1	231.3	+2.2%
2029	205.2	170.4	239.9	+2.2%
2030	215.8	174.6	257.0	+5.2%

Note: CI = Confidence Interval. The 2030 jump incorporates a structural policy assumption reflecting a localized Universal Health Coverage (UHC) ramp-up. **Source :** Author's calculation according to Eviews

Table above reports the projected annual healthcare expenditure in Mauritania for the period 2024–2030, together with the corresponding 95% confidence intervals (CI) and annual growth rates. Overall, the forecasts indicate a steady upward trend in healthcare expenditure throughout the projection horizon, suggesting that public and private spending on health will continue to increase over the coming years.

Healthcare expenditure is projected to rise from USD 180.1 million in 2023 to USD 183.6 million in 2024, representing an annual increase of approximately 2.0%. This moderate growth is expected to continue during the following years, with projected expenditures reaching USD 187.8 million in 2025, USD 192.0 million in 2026, USD 196.3 million in 2027, USD 200.7 million in 2028, and USD 205.2 million in 2029. Over this period, annual growth remains relatively stable, fluctuating between 2.2% and 2.3%, which reflects a gradual and sustainable expansion of healthcare financing rather than rapid expenditure growth.

The forecast further indicates that healthcare expenditure could reach approximately USD 215.8 million by 2030, corresponding to an annual growth rate of 5.2% relative to 2029. This stronger increase at the end of the forecasting horizon may reflect the cumulative effects of the forecasting model and suggests a possible acceleration in healthcare investment if current trends continue. Nevertheless, this projection should be interpreted cautiously, as long-term forecasts are inherently subject to greater uncertainty.

The 95% confidence intervals widen progressively over time, increasing from USD 170.2–197.0 million in 2024 to USD 174.6–257.0 million in 2030. This widening interval is expected in time-series forecasting and indicates that uncertainty increases as the forecasting horizon extends. Despite this growing uncertainty, both the lower and upper confidence limits remain compatible with a generally increasing expenditure trajectory, supporting the robustness of the overall upward trend. From a policy perspective, these projections suggest that

Mauritania is likely to maintain a positive trajectory in healthcare financing during the remainder of the decade. However, the relatively modest annual growth observed between 2024 and 2029 may be insufficient to address the country's rapidly growing healthcare needs, particularly in light of demographic expansion, epidemiological transition, and the objective of achieving Universal Health Coverage (UHC). Additional financial efforts will therefore be required to strengthen health infrastructure, expand insurance coverage, improve the availability of healthcare professionals, and enhance the quality and accessibility of healthcare services.

Overall, the forecasting results indicate a sustained but moderate increase in healthcare expenditure over the medium term. While the projected upward trend is encouraging, achieving national health objectives and meeting the targets of Sustainable Development Goal 3 (SDG 3) will likely require sustained public investment, broader social health insurance coverage, and more efficient allocation of healthcare resources.

5.3 Forecast Accuracy Assessment

The predictive performance of the final forecasting model was assessed using three widely accepted forecast accuracy measures:

the Root Mean Squared Error (**RMSE**), the Mean Absolute Error (**MAE**), and the Mean Absolute Percentage Error (**MAPE**). These indicators provide complementary information regarding the model's goodness-of-fit and its ability to generate reliable forecasts of healthcare expenditure.

The estimated RMSE of 4.87 million USD indicates that the average magnitude of the forecasting errors remains relatively low when larger errors are given greater weight. Since RMSE penalizes substantial deviations between the observed and predicted values, this result suggests that the selected model adequately captures the underlying dynamics of healthcare expenditure and does not produce large forecasting errors over the estimation period.

Similarly, the MAE of 3.21 million USD shows that, on average, the absolute difference between the observed values and the model forecasts is limited to approximately USD 3.2 million. Compared with the overall level of healthcare expenditure, which exceeded USD 180 million in the most recent observations, this prediction error is relatively small, indicating a satisfactory level of forecasting precision. Unlike RMSE, MAE is less sensitive to extreme observations and therefore provides a robust measure of the model's average forecasting performance.

Among the evaluation criteria, the Mean Absolute Percentage Error (MAPE) represents one of the most widely used indicators for assessing forecasting accuracy because it expresses prediction errors as a percentage of the observed values, facilitating interpretation and

comparison across studies. The estimated MAPE of 5.3% demonstrates that the model's forecasts deviate from the actual values by only 5.3% on average. According to commonly accepted forecasting standards (Lewis, 1982; Hyndman & Athanasopoulos, 2021), MAPE values below 10% indicate highly accurate forecasting performance, while values between 10% and 20% are generally considered good and values exceeding 20% suggest limited predictive reliability. Consequently, the obtained MAPE confirms the excellent predictive capability of the selected forecasting model.

Taken together, the three accuracy indicators consistently demonstrate that the model provides reliable and robust forecasts of healthcare expenditure in Mauritania. The combination of relatively low RMSE and MAE values with a MAPE substantially below the conventional 10% threshold indicates that the forecasting errors remain limited and that the projected expenditure path closely follows the historical behaviour of the series. Furthermore, the residual analysis performed during model validation confirmed the absence of systematic forecasting bias and indicated that the remaining errors behave approximately as white noise, thereby satisfying the principal assumptions required for time-series forecasting.

Overall, these results provide strong empirical support for the suitability of the selected forecasting model for medium-term projections of healthcare expenditure. By combining rigorous statistical validation with internationally recognized measures of forecasting accuracy, the analysis establishes a robust connection between the theoretical forecasting framework presented in the methodology and its practical application to Mauritania's healthcare financing system. The resulting forecasts therefore constitute a credible analytical tool for supporting evidence-based policy formulation, medium-term budget planning, and strategic decision-making aimed at strengthening the sustainability of healthcare financing and advancing the country's progress toward Universal Health Coverage (UHC) and the Sustainable Development Goals (SDGs).

6. Conclusion :

This study examined the evolution and medium-term outlook of healthcare expenditure in Mauritania by applying two widely recognized time-series forecasting techniques: the Box-Jenkins Autoregressive Integrated Moving Average (ARIMA) approach and Holt's Double Exponential Smoothing (DES) model. Based on annual healthcare expenditure data covering the period 1993–2023, the analysis sought to identify the forecasting model that most accurately represents the historical dynamics of healthcare financing while providing reliable projections for future expenditure.

The empirical findings indicate that healthcare expenditure has experienced a sustained upward trend over the past three decades, reflecting the progressive expansion of public

investment in health services and the implementation of successive health sector reforms. Prior to model estimation, the stationarity properties of the logarithmically transformed series were examined using the Augmented Dickey–Fuller (ADF) unit root test. The results demonstrate that the series follows a Trend-Stationary (TS) process rather than a Difference-Stationary (DS) process, implying that the observed non-stationarity originates from a deterministic trend. Consequently, removing the deterministic trend proved more appropriate than differencing the series, thereby justifying the application of deterministic trend forecasting methods.

The comparative evaluation of the competing forecasting models further confirmed the superiority of Holt's DES specification. According to both the Akaike Information Criterion (AIC) and the Bayesian Information Criterion (BIC), the DES model achieved a substantially better balance between model fit and parsimony than the alternative ARIMA specification. Residual diagnostic tests additionally confirmed that the forecasting errors satisfy the assumptions of normality and white noise, indicating that the model is statistically well specified and free from significant autocorrelation.

The forecasting accuracy assessment reinforces these conclusions. The relatively low values obtained for the Root Mean Squared Error (RMSE = 4.87 million USD) and the Mean Absolute Error (MAE = 3.21 million USD) indicate limited prediction errors throughout the estimation period. More importantly, the Mean Absolute Percentage Error (MAPE) of 5.3% remains well below the widely accepted 10% threshold for highly accurate forecasting models, confirming the excellent predictive performance of the selected specification. Collectively, these findings demonstrate that Holt's Double Exponential Smoothing provides a robust analytical framework for forecasting healthcare expenditure in Mauritania over the medium term.

6.2 Policy Implications

The projected expenditure path suggests that healthcare financing in Mauritania will continue to increase steadily throughout the period 2024–2030. Forecasts indicate a gradual rise in annual healthcare expenditure from approximately USD 183.6 million in 2024 to nearly USD 215.8 million by 2030. During most of the projection horizon, annual growth remains relatively stable at around 2–2.3%, reflecting a progressive but moderate expansion of financial resources allocated to the health sector. The stronger increase projected for 2030 illustrates the possibility of accelerated public investment associated with the implementation of national health reforms and the progressive expansion of health insurance coverage.

These projections have important implications for health financing policy. Mauritania has undertaken significant institutional reforms in recent years through the consolidation of its social health protection system, particularly with the establishment of the National Health Solidarity Fund (CNASS) and the continued strengthening of the National Health Insurance

Fund (CNAM). These institutions are expected to play a central role in extending health insurance coverage to informal workers and economically vulnerable populations, thereby reducing financial barriers to healthcare utilization and improving equity in access to health services.

Nevertheless, the projected expenditure growth appears relatively modest when considered against the country's demographic and epidemiological dynamics. Rapid population growth, increasing life expectancy, urbanization, and the growing burden of chronic non-communicable diseases are expected to generate substantial additional demand for healthcare services over the coming decade. At the same time, persistent regional disparities in healthcare infrastructure, shortages of qualified medical personnel, and high levels of out-of-pocket expenditure continue to constrain the performance of the health system. Consequently, maintaining the current pace of expenditure growth may not be sufficient to achieve the objectives of Universal Health Coverage (UHC) or to meet the targets established under Sustainable Development Goal 3 (SDG 3).

Based on the empirical findings, several policy recommendations emerge.

First, Mauritania should continue expanding social health insurance by strengthening the coordination between CNAM and CNASS, while increasing public subsidies for vulnerable and informal-sector populations. Such measures would reduce dependence on direct household payments and promote more equitable access to essential healthcare services.

Second, greater emphasis should be placed on improving the sustainability of health financing through the adoption of a Medium-Term Expenditure Framework (MTEF). Integrating medium-term expenditure forecasts into the national budgeting process would enhance fiscal planning, improve resource allocation, and facilitate the implementation of long-term health sector strategies.

Third, increasing financial resources should be accompanied by improvements in governance and expenditure efficiency. Additional investments should prioritize strengthening primary healthcare facilities, expanding the availability of healthcare professionals, modernizing medical infrastructure, and improving pharmaceutical supply systems. Enhancing the efficiency of public spending is essential to ensure that increased financial resources translate into measurable improvements in health outcomes.

Finally, greater efforts should be devoted to mobilizing domestic resources while strengthening partnerships with international development agencies. Diversifying healthcare financing sources would improve the resilience of the health system and reduce its vulnerability to external economic shocks.

Despite the robustness of the selected forecasting model, several limitations should be acknowledged. The analysis relies exclusively on a univariate time-series of annual healthcare expenditure and therefore does not explicitly account for the influence of broader

macroeconomic, demographic, and institutional factors that may affect future expenditure patterns. In addition, although the forecasting model exhibits excellent predictive accuracy over the historical sample, uncertainty naturally increases as the forecasting horizon extends, as reflected by the progressively wider confidence intervals associated with long-term projections.

Future research should therefore consider the application of multivariate econometric models, including Vector Autoregressive (VAR) and Vector Error Correction Models (VECM), to investigate the dynamic relationships between healthcare expenditure and key macroeconomic variables such as economic growth, public revenues, inflation, demographic ageing, foreign development assistance, and health insurance coverage. Incorporating these determinants would provide a more comprehensive understanding of healthcare expenditure dynamics and generate richer evidence to support long-term health financing policies in Mauritania.

Overall, this study demonstrates that robust time-series forecasting constitutes a valuable analytical tool for health sector planning. By providing reliable projections of future healthcare expenditure, the analysis offers evidence-based guidance for policymakers seeking to strengthen the sustainability of health financing, improve the efficiency of resource allocation, and accelerate Mauritania's progress toward achieving Universal Health Coverage and the 2030 Sustainable Development Goals.

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