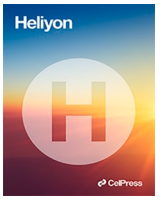
Heliyon 10 (2024) e24268

Contents lists available at ScienceDirect

Heliyon

journal homepage: www.cell.com/heliyon



Research article

Effects of healthcare spending on public health status: An empirical investigation from Bangladesh

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ARTICLE INFO

JEL Code: H5
H51
I110

Keywords:
Public healthcare spending
Life expectancy
Mortality rate
Maternal health
Infectious disease
Bangladesh

ABSTRACT

The escalation of healthcare spending in many nations, particularly in emerging countries such as Bangladesh, may be largely attributed to the growing demand for healthcare services. Evidently, there has been a significant expansion in the public funding allocated to the health sector in Bangladesh, intending to enhance health outcomes. Therefore, the purpose of this study was to examine the impact of healthcare expenditure on health outcomes, specifically focusing on the reduction in different mortality rates and the transmission of various infectious diseases. A total of 30 years of data (1990–2019) on the health sector of Bangladesh were collected from different national and international sources. The Vector Autoregression with Exogenous Variables (VARX) model was employed to determine the effects of healthcare expenditure on health outcomes. Results revealed that the per capita health expenditure and the number of doctors showed a significant positive impact on life expectancy and maternal and child health. Also, the government's annual budget on the health sector and number of doctors had a significant positive impact on lowering deaths by Diphtheria, Cholera, Tuberculosis, and Malaria diseases. In order to develop a sustainable healthcare system within the nation, it is imperative for the government to prioritize the allocation of sufficient and effective healthcare funding to cater to the needs of the populace.

1. Introduction

Government healthcare spending is a crucial factor in enhancing the overall health status of a nation's populace. The healthcare investment made by the government has positive outcomes not just in terms of saving lives but also in terms of economic benefits [1,2]. Eventually, the country becomes better equipped to deal with any health-related catastrophe like COVID-19, with strong and powerful health systems. Healthcare spending is even more significant for developing nations, given their vulnerable healthcare systems [3,4]. Developing countries' healthcare systems suffer a mix of heightened danger and less healthcare ability to respond due to lower per

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https://doi.org/10.1016/j.heliyon.2024.e24268
Received 15 August 2022; Received in revised form 21 October 2023; Accepted 5 January 2024
Available online 6 January 2024

capita health spending, a higher underlying burden of disease, and larger population density [5]. Therefore, it is important to investigate how healthcare spending affects the health of the population in a developing nation like Bangladesh.

A crucial requirement for improving the efficacy of a nation's healthcare system is the provision of sufficient budgetary allocation [1]. The budget allocation for the health sector by the Government of Bangladesh has had an upward trajectory since the country's independence. Notably, the budget allocated for the fiscal year 2022-23 surpasses the allocations made in previous years [6] but it is still inadequate to meet the needs of the substantial population since over 20 % of individuals reside below the national poverty threshold [7]. The government spends 2.34 % of the national GDP on the public health care system which is the lowest among the neighboring countries in Asia and the Pacific [8] and it is lower than the required level (5 %) recommended by the World Health Organization [9]. On the other hand, in the fiscal year of 2022–23, the allocation for the health sector in Bangladesh dropped down to only 5.43 % of the total budget which is much lower than the recommendation of the WHO to allocate at least 15 % of the total annual budget [9]; eventually, it highlights the researchers' focus on doing this empirical research.

Despite facing limited budgetary allocation, Bangladesh has achieved some notable progress in reducing mortality rates associated with infectious and chronic diseases, including Diphtheria, Cholera, Tuberculosis, and Malaria. This accomplishment can be attributed to the successful implementation of the Extended Immunization Program and widespread public awareness campaigns throughout the nation. Notwithstanding the notable advancements in health indicators, the health system of the nation is now grappling with significant challenges stemming from inadequate financial resources and deficiencies in skilled human resources, infrastructure, and logistical support [10]. For instance, the doctor-patient ratio in Bangladesh was only 5.99 per 10,000 people in 2019, putting the country second from the bottom among South Asian countries [11]. Furthermore, the number of available hospital beds in the country combining both private and public hospitals in 2019 is only 0.87 per 1000 persons which is less than 10 % of WHO recommendations (a minimum of three beds per 1000 patients) [12]. Furthermore, a significant number of hospitals, particularly those located in rural regions, suffer from a dearth of crucial medical apparatus. This includes the absence of vital diagnostic instruments like digital X-ray machines, CT scanners, ultrasonogram and echocardiography devices, microscopes, and other necessary equipment. This inadequacy further exacerbates the vulnerability of the healthcare system and demands more budgetary allocation.

However, healthcare spending and outcomes, like mortality and life expectancy, have a complicated relationship [13]. It is unclear how and why healthcare costs affect health outcomes. According to studies, nations with higher healthcare spending have populations with longer life expectancies and lower mortality rates [14–16]. According to data from the World Health Organization, for instance, nations like Switzerland, Norway, and the United States tend to have longer life expectancies than nations like Kenya, Nigeria, and Haiti which spend less on healthcare per person [17]. It is crucial to remember that merely increasing healthcare spending does not ensure improved health outcomes. A key influence in determining health outcomes is also played by social and economic factors like income, education, availability of good food, living conditions, and good medical care [13,18]. Therefore, it is necessary to do more thorough investigations to determine whether and how healthcare spending is related to improved public health.

Therefore, the objective of this study is to investigate numerous factors, including the influence of healthcare expenditure on life expectancy, maternal and child mortality rates, as well as the prevalence of severe infectious diseases such as Diphtheria, Cholera, Tuberculosis, and Malaria mortality in Bangladesh. This study makes a two-fold contribution. This study uses a 30-year time series data set to investigate changes in the health sector and the factors that influence maternal, child, and infectious disease death rates. Second, our study has policy implications in several ways, thus it can help revise the National Health Policy 2011 since we focused on certain important policy-relevant variables to better understand the current condition of different health indicators in Bangladesh which can aid the government in reaching Sustainable Development Goal-3 (good health and well-being) by 2030. The study tends to give facts and helpful insights on healthcare finance, which may be relevant in other developing nations where applicable.

2. Review of related literature

Globally, a substantial amount of literature has examined whether government spending influences a country's public health [19]. For instance, research conducted in the United States using a lagged longitudinal model [20], discovered a positive correlation between public expenditure and health results. There is a plausible association between government spending and health outcomes in emerging nations [21]. McCullough et al. [22] examined the effects of public and private health spending on 195 nations' life expectancy at birth and infant mortality. Their findings suggest that public health spending generally promotes health more than private spending does. Using a simulated Computable General Equilibrium (CGE) model and disaggregated analysis of 1970–2008 data [23,24], discovered that public health investment has a beneficial effect on health results and economic growth in Nigeria. Similar findings were also reported by Refs. [25,26]. In the instance of Ghana and Caribbean nations, panel OLS results suggested that significant life expectancy and lower mortality can be attained by healthcare spending [27,28]. In contrast, a study in Lebanon examining the trend of public expenditure on health from 1962 to 2007 revealed no correlation in either the short or long term [29]. Therefore, further research is required to examine the inconsistent findings regarding the impact of healthcare expenditure on the overall health condition of the population.

3. Methods

3.1. Definition of variables and data source

Healthcare spending and other health-related data were included since the objective of this research is to assess how healthcare finance affects health outcomes. For analysis, different independent variables i.e., annual health expenditure by the government as a

percentage of GDP, per capita health expenditure, number of registered doctors, number of hand/shallow tube-wells in rural areas, number of public and private medical colleges, and private hospitals were used as proxy variables of healthcare spending. The reason for inserting the variable 'shallow tube-wells' along with other health indicators is that the major infectious diseases (i.e., Diphtheria, Cholera, Malaria, and Tuberculosis) are mainly waterborne and can be prevented if safe water is available. The study used 30-year annual time-series data, from 1990 to 2019, collected from secondary sources.[2] The sources and definitions of the data sources used in this study are summarized in Table 1.

3.2. Data analysis

3.2.1. Stationarity issues in time series data

Empirical work based on time series data relies on stationarity. If a time series is stationary, its mean, variance, and autocovariance remain the same no matter at what point we measure them; that is, they are time-invariant [30]. A variable that is stationary or non-stationary can be tested by the unit root test. There are various statistical inferences available to check the unit root of time series data. Among them, the Dickey-Fuller and Augmented Dickey-Fuller (ADF) tests are commonly used for the stationarity test. However, higher-order serial correlation cannot be accommodated through the Dickey-Fuller test. In this regard, the ADF [31] and Phillips-Perron (PP) test suggested by Ref. [32] was employed to test the stationarity of variables for this study. The testing procedure for the ADF test is as follows:

$$\Delta Y_t = \beta_1 + \beta_{2t} + \rho Y_{t-1} + \delta_i \sum_{i=1}^{m} \Delta Y_{t-1} + \varepsilon_t$$

Where ε_t is a pure white noise error term and $\Delta Y_{t-1} = (Y_{t-1} - Y_{t-2})$, $\Delta Y_{t-2} = (Y_{t-2} - Y_{t-3})$ etc. If the time series has a unit root (non-stationary), the first differences of such time series are stationary [30]. Therefore, we take the first differences in the time series by using the natural logarithm to linearize the variable for easy attainment of stationarity. Once, time series variables exhibit the stationarity property, the econometric model was employed to show the effects of healthcare spending on different health outcomes. Besides, the Durbin Watson (DW) test was used to detect the first-order autocorrelation. The result of Durbin's alternative serial autocorrelation confirmed that there was no serial autocorrelation.

3.2.2. The econometric model

Vector autoregression (VAR) is a stochastic process model used to capture the linear interdependencies among multiple time series. A VAR with exogenous variable (VARX) model was employed to show the effect of healthcare spending on the different health outcome variables. The VARX (p, s) model (Scott and Hatemi, 2008) is written as:

$$y_{ti} = c + \sum_{i=1}^{p} \beta_i y_{t-i} + \sum_{i=0}^{p} \delta_i x_{t-i} + \varepsilon_t$$

Where c is a constant serving as the intercept of the model, $x_t = (x_{1t} \ldots\ldots x_{rt})$ is an r-dimensional time series vector, β_i are $(k \times k)$ endogenous coefficient matrices (with i having values from 1 to p), δ_i are $(k \times r)$ exogenous coefficient matrices, and ε_t is a $(k \times 1)$ vector describing noise in the data.

In our estimated empirical model, y_i ranges from 1 to 9. Where $i = 1$: average life expectancy at birth; $i = 2$: maternal mortality rate/100000 live births; $i = 3$: neonatal mortality rate/1000 live births; $i = 4$: infant mortality rate/1000 live births; $i = 5$: underaged (less than five years) mortality rate/1000 live births; $i = 6$: number of deaths by Diphtheria/100000 population; $i = 7$: number of deaths by Cholera/100000 population; and $i = 8$: number of deaths by Tuberculosis/100000 population; $i = 9$: number of Malaria death/100000 population.

Moreover, X_1 = Government health budget; X_2 = per-capita health expenditure; X_3 = number doctors; X_4 = number of hospital beds; X_5 = number of distributed hand/shallow tube-wells in rural areas; X_6 = number of government medical colleges; and X_7 = number of private medical colleges.

4. Results and discussion

4.1. Result of unit root test

It is crucial to test for the unit root to investigate the stationary property of the time series data set before moving on with the econometric analysis. Each distinctive time series data had undergone ADF and PP testing. The results of the PP test and ADF test are displayed in Table 2.

Table 2 revealed that the government health budget did not have a unit root or non-stationarity cannot be rejected at level. Therefore, we cannot use the government health budget in health sector as straightforward. As there was a unit root or non-stationarity

[2] Some data were not available in the online sources mentioned in Table 1 as per our designated time period. Thus, for the sake of brevity and uniformity of time period of all variables, we took the missing data from the government annual report of respective ministries.

Table 1
Definition of variables and sources of data.

Variables	Description	Data source
Government health budget	Annual health expenditure by the government (% of GDP)	WDI (https://data.worldbank.org/indicator/SH.XPD.CHEX.GD.ZS?locations=BD) and BBS (https://bbs.portal.gov.bd/)
Per capita health expenditure	The total amount that a country spends on health for an individual (USD)	WDI (https://data.worldbank.org/indicator/SH.XPD.CHEX.PC.CD?locations=BD)
Number of doctors	Number of doctors/physicians (per 1000 population)	WDI (https://data.worldbank.org/indicator/SH.MED.PHYS.ZS?locations=BD)
Number of beds	Number of hospital beds (per 1000 population)	WDI (https://data.worldbank.org/indicator/SH.MED.BEDS.ZS?locations=BD)
Shallow tubewells	No. of hand/shallow tube wells in rural areas.	BBS Annual Report (https://bbs.portal.gov.bd/)
Government medical college	No. of government medical college (per 1 million population)	DGHS (https://old.dghs.gov.bd/index.php/en/data)
Private medical college	No. of private medical college (per 1 million population)	DGHS (https://old.dghs.gov.bd/index.php/en/data)
Life expectancy at birth	Average time people expect to live, based on the year of their birth (years)	WDI (https://data.worldbank.org/indicator/SP.DYN.LE00.IN?locations=BD)
Maternal mortality	Death of a woman while pregnant or within 42 days of termination of pregnancy (per 100,000)	World Data Atlas (https://opendataforafrica.org/atlas/Bangladesh/topics/Health/Health-Status/Maternal-mortality-ratio)
Infant mortality	Death of children under the age of one (per 1000 live births)	World Data Atlas (https://opendataforafrica.org/atlas/Bangladesh/topics/Health/Health-Status/Infant-mortality-rate)
Neonatal mortality	A death during the first 0–27 days of a child's life (per 1000 live births)	World Data Atlas (https://opendataforafrica.org/atlas/Bangladesh/topics/Health/Health-Status/Neonatal-mortality-rate)
Mortality under age 5	Death of children under the age of five (per 1000 live births)	World Data Atlas (https://opendataforafrica.org/atlas/Bangladesh/topics/Health/Health-Status/Under-5-mortality-rate)
Diphtheria	Death by Diphtheria/100,000 population	World Data Atlas (https://opendataforafrica.org/atlas/Bangladesh/topics/Health/Communicable-Diseases/Diphtheria-cases)
Cholera	Death by Cholera/100,000 population	World Data Atlas (https://knoema.com/atlas/Bangladesh/topics/Health/Communicable-Diseases/Cholera-deaths)
Tuberculosis	Death by Tuberculosis/100,000 population	World Data Atlas (https://opendataforafrica.org/atlas/Bangladesh/topics/Health/Communicable-Diseases/Tuberculosis-cases)
Malaria	Death by Malaria/100,000 population	World Data Atlas (https://knoema.com/atlas/Bangladesh/topics/Health/Risk-factors/Malaria-cases)

Note: WDI = World Development Indicators of World Bank; DGHS = Directorate General of Health Services; BBS = Bangladesh Bureau of Statistics; WHO = World Health Organization.

problem in the model, the solution of non-stationarity was to take the first differences of the time series. When we took the first differences in the health budget, it exhibited stationarity property. We also performed a stationarity test for other independent variables. After taking the first differences all independent variables were stationary. In the case of dependent variables, the level value of life expectancy at birth had a stationarity property. But in the case of maternal mortality, infant mortality, neonatal mortality, and mortality under age 5 the first differences were taken to make stationery. To consolidate the findings obtained from the ADF test, we further employed the Phillips-Perron (PP) test. The outcome goes in line with the result of the ADF test. Besides, the results of the ADF test and PP test showed that neither of the variables is stationary at the 2nd difference. Hence, we proceeded to run the time series

Table 2
Findings of unit root test.

	ADF test			PP test		
Variables	Level	First difference	Decision	Level	First difference	Decision
Government health budget	−2.01	−5.22***	I (1)	−1.99	−4.55***	I (1)
Per capita health expenditure	−1.02	−4.27***	I (1)	−2.03	−5.87***	I (1)
Number of doctors	−0.89	−6.09***	I (1)	−1.09	−5.34***	I (1)
Number of hospital beds	−0.78	4.98***	I (1)	−0.56	5.21***	I (1)
Shallow tubewells	−2.01	−6.78***	I (1)	−0.98	−8.96***	I (1)
Government medical colleges	−1.11	−4.11***	I (1)	−3.67**	−6.75**	I (0)
Private medical colleges	−2.56	−7.89***	I (1)	−3.01	−8.87***	I (1)
Life expectancy at birth	−2.95	−7.08***	I (1)	−1.19	−5.06***	I (1)
Maternal mortality	−3.43**	−4.88***	I (0)	−3.88**	−5.06***	I (0)
Infant mortality	−1.7***	−9.02***	I (0)	−4.42***	−5.99***	I (0)
Neonatal mortality	−3.99**	−10.03***	I (0)	−5.88***	−6.98***	I (0)
Mortality under age 5	−4.62**	−6.88***	I (0)	−4.34***	−7.09***	I (0)
Diphtheria	−1.04	−7.90***	I (1)	−1.01	−6.70***	I (1)
Cholera	−1.92	−7.21***	I (1)	−2.11	−6.93***	I (1)
Tuberculosis	−0.12	−4.67***	I (1)	−1.54	−6.89***	I (1)
Malaria	−1.46	3.98***	(I)	−0.23	4.49***	I (1)

Note: *** and ** denote statistically significant at 1 % and 5 % level of significance respectively, I(0) and I(1) indicate stationary at the level and first difference, respectively.

econometric model.

4.2. Effect of healthcare expenditure on the major health outcomes

Results from the VARX model were reported in Table 3 for life expectancy at birth, maternal mortality rate, and child mortality rate. The results showed that an increase in the total healthcare budget by the government and per capita health expenditure is more likely to raise life expectancy at birth. The results also revealed that, if the number of registered doctors increased, it would lead to an improvement in life expectancy. Even access to safe drinking water or an increase in the number of shallow tube-wells leads to increased life expectancy. A good number of shallow tube-well had been distributed throughout the country by the different initiatives of government. By using safe water for drinking and daily usage, rural people especially were not affected by water-transmitted diseases. Ultimately, people were leading a healthy and active life, which increased the average life expectancy of the people in Bangladesh. This finding is like the previous studies [16,33,34] which found a small amount of healthcare expenditure in developing countries would certainly have a bigger impact on life expectancy.

In the case of maternal mortality, the government healthcare budget, per capita health expenditure, and number of hospital beds were more likely to decrease the death rate (Table 3). Similar results were found in the study of [35,36]; and [37] who reported that health expenditures significantly improve maternal health. The healthcare budget covered the different maternal health services including antenatal care, basic essential obstetric care, family-planning services, essential newborn care, etc. which eventually improved maternal health [38]. Nutritional deficit during pregnancy was reduced due to higher per capita expenditure for nutritional food such as milk, eggs, fruits, leafy vegetables, etc. Increasing the number of hospital beds accelerated facility penetration, particularly easy access to duty doctors who provide proper treatment during births, lowering maternal mortality rates [39].

An increase in government expenditure on health, the per capita health expenditure, and the number of hospital beds tend to lower the neonatal mortality rate, infant mortality rate, and mortality rate for underaged children (who are less than five years old) (Table 3). The finding of this study is in line with the previous studies [35,40,41], which show that public health expenditure and neonatal mortality have a negative relationship. In the case of infant mortality rate and mortality rate for the underaged, [42–45]; and [46] also found similar results. Prematurity is a commanding cause of newborn deaths; two-thirds of these deaths can be prevented by performing effective health measures at birth and in the first week of birth through skilled health professionals at hospitals [47]. However, an increase in healthcare spending also results in higher hospital budgets and increases the availability of hospital resources including the number of beds and skilled health workers, which in turn reduce the neonatal and infant mortality rate [42,48]. Neonatal babies often suffering from asphyxia, and preterm or low-birth-weight babies, require public healthcare funding because higher-technology interventions such as assisted ventilation for neonates are extremely costly. On the other hand, the babies who were less than one year and less than five years old also suffered from colds, coughs, fevers, and vomiting. Modernization of medical services has lowered such cases in recent. In addition, urban parents spend more money on the betterment of their children's health. Urban parents take their children to the hospital without leaving them at home for advanced treatment. Although the cost of treatment was high, urban parents used to go to private hospitals for better treatment of their babies.

4.3. Effect of healthcare spending on infectious diseases

The effect of healthcare financing on four diseases- Diphtheria, Cholera, Tuberculosis, and Malaria illustrated in Table 4. An increase in the government health budget and the number of doctors is likely to decrease the number of deaths by Diphtheria. A proportion of the government health budget accelerates the quality production and availability of vaccines which tends to reduce the mortality rate of Diphtheria. As the number of registered doctors grows, so do the treatment options for Diphtheria patients, lowering the mortality rate significantly. On the other hand, if the government health budget, per capita health expenditure, number of doctors, number of hospital beds, and shallow tubewell increases, the number of deaths by Cholera would decrease. Previous studies by Refs. [49,50] suggested that healthcare spending is a prerequisite to reducing cholera deaths by 90 % worldwide by 2030. The majority of individuals affected by Cholera in Bangladesh were residents of rural regions and slums, with a significant proportion seeking admission or treatment in government healthcare hospitals. The country had a notable decline in Cholera mortality rates due to the simultaneous rise in the availability of government hospital beds and the number of registered physicians, hence enhancing access to

Table 3
Effect of healthcare expenditure on life expectancy, maternal and child mortality.

Variables	Life expectancy	Maternal mortality	Child mortality		
			Neonatal mortality rate	Infant mortality rate	Mortality rate underage of 5
Constant	0.82[a] (0·00)	−3.09[a] (0·00)	−1.75[a] (0·00)	−1.11[a] (0·00)	−2.01[a] (0·00)
Government health budget	0.19[a] (0·00)	−0·06** (0·04)	−0.52[a] (0·00)	−0·21** (0·02)	−0·29** (0·01)
Per capita health expenditure	0·02* (0·06)	−0·32[a] (0·00)	−0·09[a] (0·00)	−0·02[a] (0·00)	−0·31[a] (0·00)
Number of doctors	0·01[a] (0·00)	−0·16[a] (0·00)	−0·09[a] (0·00)	−0·03[a] (0·00)	−0·12[a] (0·00)
Number of hospital beds	0·07 (0·21)	−0·11** (0·01)	−0·18** (0·05)	−0·07** (0·03)	−0·04* (0·09)
Shallow tubewells	0·28[a] (0·00)	−0·13 (0·82)	−0·02 (0·97)	−0·18 (0·13)	−0·09 (0·14)
Government medical colleges	0·03 (0·75)	−0·13 (0·12)	−0·02 (0·99)	−0·09 (0·19)	−0·09 (0·80)
Private medical colleges	0·09 (0·88)	−0·05 (0·26)	−0·10 (0·44)	−0·01 (0·98)	−0·01 (0·99)

[a] , ** and * denotes significance at 1 %, 5 % and 10 % level. p-statistics are reported in parenthesis.

Table 4
Effect of healthcare expenditure on diseases.

Variable	Diphtheria	Cholera	Tuberculosis	Malaria
Constant	−2·20 (0·68)	3.09[a] (0·00)	0.82[a] (0·00)	1.27[a] (0.00)
Government health budget	−0·63** (0·03)	−0·29[a] (0·00)	−0·18[a] (0·00)	−0.04* (0.08)
Per capita health expenditure	−0·21 (0·11)	−0·19* (0·09)	−0·07 (0·48)	−0.91** (0.05)
Number of doctors	−1.04[a] (0·00)	−0·87** (0·02)	−0.29** (0·05)	−0.03* (0.08)
Number of hospital beds	−1·77 (0·89)	−2.09[a] (0·00)	−0·78 (0·25)	−1.21[a] (0.00)
Shallow tube-well	−0·29 (0·89)	−1.01** (0·02)	−0·42 (0·35)	−0.16 (0.59)
Government medical colleges	0.25 (0·18)	−0.02* (0·08)	−0·43* (0·08)	−0.62** (0.03)
Private medical colleges	−0·67 (0·19)	−0·02 (0·98)	−0·81** (0·06)	−0.18** (0.04)

[a] , ** and * denotes significance at 1 %, 5 % an 10 % level. p-statistics are reported in parenthesis.

adequate medical care. Due to the low cost of treatment in government hospitals, all classes of people, especially the poor class, could take the services with the lowest possible costs, which ultimately reduced Cholera deaths. Although oral cholera vaccines have been used progressively and available at a reasonable cost to curtail cholera outbreaks over the past years, they have not been used yet on a large scale to control endemic cholera in Bangladesh [51]. On the other hand, Bangladesh observed cholera outbreaks in different urban areas in the past few years, particularly in the slum areas. Therefore, the Government should promote different campaigns and mass cholera vaccination programs in consolidation with other interventions to control cholera and water-borne diseases.

In case of Tuberculosis in Bangladesh, the government healthcare budget, number of doctors, government medical colleges, and private medical colleges help to decrease the number of deaths by Tuberculosis. The cost of Tuberculosis treatment was free, and all classes of people were getting improved quality treatment in government hospitals. The medical college students arranged a campaign to make people aware of this disease, and medical facilities were provided to the people very easily and without any costs. So, the number of deaths by Tuberculosis has decreased in recent years. The findings conclude that health expenditure, especially the public fund, is compulsory to develop health facilities, and it yielded improved health system operations. This result from the current study conforms to the findings of other studies that health expenditure is an essential determinant of health outcomes [52]. Similar findings were also obtained for Malaria as the government healthcare budget, per capita health expenditure, and number of doctors significantly reduced the death by malaria in Bangladesh. The result is supported by the previous studies of [53] who found that government health expenditure reduces Malaria deaths in Nigeria. The study also revealed that an increase in number of hospital beds, government medical colleges, and private medical colleges decreases the deaths by Malaria. Now a day, government and private medical colleges provide modern treatment to reduce diagnostically severe malaria, particularly in children, because of ad hoc chloroquine use, could significantly mitigate the host immune response postulated to recrystallize other diseases (e.g., Burkitt's Lymphoma) [54].

5. Conclusion and policy guidance

The healthcare budget of the government in Bangladesh has exhibited an increased trajectory since 1990. Although the per capita health expenditure increased in Bangladesh, the percentage share of the health sector budget in proportion to the total national budget has decreased over the last four decades. On the other hand, Bangladesh focused on controlling child mortality and gave more importance to maternal health over time. As a result, significant improvement was achieved in terms of controlling child mortality, and both maternal and child health improved over the years. Therefore, this study tries to examine the effect of healthcare expenditure on different health outcomes considering 30 years of time series data (1990–2019) and employing the VARX model.

From the analysis, the results suggested that the government health budget greatly influenced most of the measures of health outcomes. The findings indicated that the reduction in maternal and child mortality rates, as well as the increase in life expectancy, were facilitated by several factors, including the provision of government funds to enhance the availability of hospital beds and the recruitment of a sufficient number of doctors to cater to underserved regions of the nation. Also, per capita expenditure had a positive impact on reducing maternal mortality and child mortality rates and improving life expectancy. The number of shallow tube-wells in remote areas increased people's access to safe water which consequently reduced water-borne disease probability. The government health budget significantly reduced the number of deaths by Diphtheria, Cholera, Tuberculosis, and Malaria while per capita health expenditure significantly reduced the Cholera and Malaria deaths. The number of doctors was highly significant in reducing the number of deaths by all four selected diseases, while number of hospital beds significantly dwindled the Cholera and Malaria deaths since these diseases are more prone to be hospitalized. In addition, government medical colleges and private medical colleges also significantly declined different disease deaths.

Based on our analysis, it seems obvious that better health spending improves the lives of people and enables them to carry out their daily activities properly; in other words, reduced illness costs and improved individual productivity are added to income growth. A developing country like Bangladesh must modernize the structural framework and laws relating to the health sector. In this very pandemic situation, we observed the terrible suffering of COVID-19 patients due to inadequate medical equipment (i.e., personal protective equipment (PPE), ventilator, high-flow oxygen supply, etc.). Lack of quarantine facilities in public and private hospitals and proper training of medical personnel to cope with pandemic situations, their safety equipment, transport, and residence system during working hours worsen the situation. Sufficient public spending in the health sector and its effective monitoring need to be ensured to tackle such an emergency efficiently in the future. Along with this, encouraging private investment is a must criterion for the sustainable development of the health sector, and effective implementation through the respective body is mandatory.

Even though this study develops some useful policy recommendations for the government to enhance the health of the populace. However, there are several restrictions that must be considered when interpreting the findings. First, we only consider the public budget and spending-related variables in the analysis. However, other variables, such as the proximity of the hospital to the community, human capital, and others, may be considered in subsequent analyses. Future research can also consider additional econometric models like the dynamic ARDL model or the quantile ARDL model to investigate the short- and long-term impacts of variables as well as the quantiles-wise impact. Additionally, future research might examine the differences between emerging and industrialized nations by doing a comparative examination of both.

Availability of data and material

Data can be available based on a reasonable request from the corresponding author.

Ethical statement

Since there are no human participants in this study, no ethical approval is required.

CRediT authorship contribution statement

Sabiha Sultana: Conceptualization, Data curation, Methodology, Writing - original draft. **Md. Emran Hossain:** Conceptualization, Data curation, Formal analysis, Methodology, Writing - original draft. **Md. Akhtaruzzaman Khan:** Supervision, Validation, Writing - original draft, Writing - review & editing. **Sourav Mohan Saha:** Investigation, Methodology, Resources, Writing - original draft. **Md. Ruhul Amin:** Validation, Visualization, Writing - original draft, Writing - review & editing. **Md. Masudul Haque Prodhan:** Visualization, Writing - original draft, Writing - review & editing.

Declaration of competing interest

The authors declare that they have no known competing financial interests or personal relationships that could have appeared to influence the work reported in this paper.

References

[1] G.N. Alhassan, F.F. Adedoyin, F.V. Bekun, T.J. Agabo, Does life expectancy, death rate and public health expenditure matter in sustaining economic growth under COVID-19: empirical evidence from Nigeria? J. Publ. Aff. 21 (4) (2021) e2302.
[2] M.S. Islam, M.W. Ullah, *People's Participation in Health Services: A Study of Bangladesh 's Rural Health Complex*. No. BDRWPS 7, Bangladesh Development Research Center (BDRC): Falls Church, VA, USA, 2009.
[3] R. Tripathi, S.S. Alqahtani, A.A. Albarraq, A.M. Meraya, P. Tripathi, D. Banji, F.M. Alnakhli, Awareness and preparedness of COVID-19 outbreak among healthcare workers and other residents of south-west Saudi arabia: a cross-sectional survey, Front. Public Health 8 (2020) 482, https://doi.org/10.3389/fpubh.2020.00482.
[4] E. Hossain, J. Rana, S. Islam, A. Khan, S. Chakrobortty, N.S. Ema, F.V. Bekun, COVID-19 Vaccine-Taking Hesitancy Among Bangladeshi People: Knowledge, Perceptions and Attitude Perspective, Human Vaccines & Immunotherapeutics, 2021, pp. 1–10.
[5] J.R. Khan, N. Awan, M. Islam, O. Muurlink, Healthcare capacity, health expenditure, and civil society as predictors of COVID-19 case fatalities: a global analysis, Front. Public Health (2020) 347.
[6] M.A. Sujan, Only 5.43% of total budget allocated for health sector, the Daily Star, Available via, https://www.thedailystar.net/news/bangladesh/news/neglected-yet-again-3044471, 2022. (Accessed 20 April 2023).
[7] ADB, Bangladesh and ADB. Poverty Data: Bangladesh, 2021. https://www.adb.org/countries/bangladesh/poverty.
[8] Bangladesh Health Watch, Unnayan Shamannay, Public expenditure for health sector: reviewing budget 2021-22, dhaka, Bangladesh, Available via, https://bangladeshhealthwatch.org/docs/reports_pdf/policy-brief/public-expenditure-for-health-sector-reviewing-budget-2021-22-1642952904.pdf, 2021. (Accessed 20 April 2023).
[9] Who, The Abuja Declaration: Ten Years on. 2011, World Health Organization, Geneva, 2016. Available via, https://www.who.int/healthsystems/publications/abuja_declaration/en/. (Accessed 25 April 2020).
[10] M.Z. Hassan, S.M. Fahim, A.H.A. Zafr, M.S. Islam, S. Alam, Healthcare financing in Bangladesh: challenges and recommendations, Bangladesh J. Med. Sci. 15 (4) (2016) 505–510, https://doi.org/10.3329/bjms.v15i4.21698.
[11] A. Alam, Patient, Doctors, Nurses Ratio: Bangladesh Lags Far behind its Neighbours, 2019. DhakaTribune, https://archive.dhakatribune.com/health/2019/07/21/patient-doctors-nurses-ratio-bangladesh-lags-far-behind-its-neighbours. (Accessed 18 May 2022).
[12] World Bank, The World Bank in Bangladesh, 2021. https://www.worldbank.org/en/country/bangladesh. (Accessed 18 May 2022).
[13] W.J. van den Heuvel, M. Olaroiu, How important are health care expenditures for life expectancy? A comparative, European analysis, J. Am. Med. Dir. Assoc. 18 (3) (2017) 276-e9.
[14] S. Galvani-Townsend, I. Martinez, P. Abhishek, Is life expectancy higher in countries and territories with publicly funded health care? Global analysis of health care access and the social determinants of health, Journal of Global Health 12 (2022).
[15] V. Kontis, J.E. Bennett, C.D. Mathers, G. Li, K. Foreman, M. Ezzati, Future life expectancy in 35 industrialised countries: projections with a Bayesian model ensemble, Lancet 389 (10076) (2017) 1323–1335.
[16] M.A. Bein, D. Unlucan, G. Olowu, W. Kalifa, Healthcare spending and health outcomes: evidence from selected East African countries, Afr. Health Sci. 17 (1) (2017) 247–254.
[17] World Health Organization (WHO), World health statistics 2022, Geneva, Switzerland (2022) Available via https://www.who.int/news/item/20-05-2022-world-health-statistics-2022. (Accessed 20 April 2023).
[18] A.M. Mosadeghrad, Factors influencing healthcare service quality, Int. J. Health Pol. Manag. 3 (2) (2014) 77.
[19] S.R. Singh, Public health spending and population health, Am. J. Prev. Med. 47 (5) (2014) 634–640, https://doi.org/10.1016/j.amepre.2014.05.017.
[20] J.M. McCullough, J.P. Leider, Government spending in health and nonhealth sectors associated with improvement in county health rankings, Health Aff. 35 (11) (2016) 2037–2043, https://doi.org/10.1377/hlthaff.2016.0708.

[21] T. Stubbs, A. Kentikelenis, D. Stuckler, M. McKee, L. King, The impact of IMF conditionality on government health expenditure: a cross-national analysis of 16 West African nations, Soc. Sci. Med. 174 (2017) 220–227, https://doi.org/10.1016/j.socscimed.2016.12.016.
[22] D. Ray, M. Linden, Health expenditure, longevity, and child mortality: dynamic panel data approach with global data, International Journal of Health Economics and Management 20 (2020) 99–119.
[23] E.S.O. Odior, Government expenditure on health, economic growth and long waves in A CGE micro-simulation analysis: the case of Nigeria, Eur. J. Econ. Finance Adm. Sci. 31 (2011) 99–113. https://ir.unilag.edu.ng/handle/123456789/8182.
[24] A. Nurudeen, A. Usman, Government expenditure and economic growth in Nigeria, 1970-2008: A Disaggregated Analysis. Business and Economics Journal 4 (2010).
[25] R.K. Edeme, O. Olisakwe, Public health expenditure, economic growth and health outcomes in Nigeria, Int. J. Publ. Pol. Adm. Res. 6 (1) (2019) 23–32.
[26] S.E. Nwani, I. Kelikume, Causal linkage amongst public expenditure on health, health status and Growth: new empirical evidence from Toda-Yamamoto approach for Nigeria, Journal of Scientific Research and Reports 24 (3) (2019) 1–13.
[27] R. Craigwell, D. Bynoe, S. Lowe, The effectiveness of government expenditure on education and health care in the Caribbean, Int. J. Dev. Issues 11 (1) (2012) 4–18, https://doi.org/10.1108/14468951211213831.
[28] M.K. Boachie, K. Ramu, Effect of public health expenditure on health status in Ghana, Int. J. Health 4 (1) (2016) 6, https://doi.org/10.14419/ijh.v4i1.5794.
[29] W. Saad, K. Kalakech, The nature of government expenditure and its impact on sustainable economic growth, Middle Eastern Finance and Economics 1 (4) (2009) 39–47.
[30] D.N. Gujarati, D.C. Porter, Basic Econometrics, McGrew Hill Book Co, Singapore, 2003.
[31] D.A. Dickey, W.A. Fuller, Distribution of the estimators for autoregressive time series with a unit root, J. Am. Stat. Assoc. 74 (366a) (1979) 427–431, https://doi.org/10.1080/01621459.1979.10482531.
[32] P.C. Phillips, P. Perron, Testing for a unit root in time series regression, Biometrika 75 (2) (1988) 335–346, https://doi.org/10.1093/biomet/75.2.335.
[33] J. Duba, J. Berry, A. Fang, M. Baughn, The effects of health care expenditures as a percentage of GDP on life expectancies, Res. Appl. Econ. 10 (2) (2018) 50, https://doi.org/10.5296/rae.v10i2.12654.
[34] E. Jaba, C.B. Balan, I.B. Robu, The relationship between life expectancy at birth and health expenditures was estimated by a cross-country and time-series analysis, Procedia Econ. Finance 15 (2014) 108–114, https://doi.org/10.1016/S2212-5671(14)00454-7.
[35] K.M. Nuhu, J.T. McDaniel, G.A. Alorbi, J.I. Ruiz, Effect of healthcare spending on the relationship between the Human Development Index and maternal and neonatal mortality, International health 10 (1) (2018) 33–39, https://doi.org/10.1093/inthealth/ihx053.
[36] R.H. Rana, K. Alam, J. Gow, Health expenditure, child and maternal mortality nexus: a comparative global analysis, BMC Int. Health Hum. Right 18 (1) (2018) 1–15, https://doi.org/10.1186/s12914-018-0167-1.
[37] E. Nketiah-Amponsah, The impact of health expenditures on health outcomes in sub-Saharan Africa, J. Develop. Soc. 35 (1) (2019) 134–152, https://doi.org/10.1177/0169796X19826759.
[38] M.K. Mridha, I. Anwar, M. Koblinsky, Public-sector maternal health programmes and services for rural Bangladesh, J. Health Popul. Nutr. 27 (2) (2009), https://doi.org/10.3329/jhpn.v27i2.3326.
[39] F. Tian, J. Pan, Hospital bed supply and inequality as determinants of maternal mortality in China between 2004 and 2016, Int. J. Equity Health 20 (1) (2021) 1–15.
[40] C.A.O. Tejada, L.M. Triaca, N.H. Liermann, F. Ewerling, J.C. Costa, Economic crises, child mortality and the protective role of public health expenditure, Ciência Saúde Coletiva 24 (2019) 4395–4404, https://doi.org/10.1590/1413-812320182412.25082019.
[41] M. Maruthappu, K.Y.B. Ng, C. Williams, R. Atun, T. Zeltner, Government health care spending and child mortality, Pediatrics 135 (4) (2015) e887–e894, https://doi.org/10.1542/peds.2014-1600.
[42] G.T. Kiross, C. Chojenta, D. Barker, D. Loxton, The effects of health expenditure on infant mortality in sub-Saharan Africa: evidence from panel data analysis, Health economics review 10 (1) (2020) 1–9, https://doi.org/10.1186/s13561-020-00262-3.
[43] M.M. Rahman, R. Khanam, M. Rahman, Health care expenditure and health outcome nexus: new evidence from the SAARC-ASEAN region, Glob. Health 14 (1) (2018) 1–11, https://doi.org/10.1186/s12992-018-0430-1.
[44] J. David, Infant mortality and public health expenditure in Nigeria: empirical explanation of the nexus, Timisoara J. Econ. Bus. 11 (2) (2018) 149–164, https://doi.org/10.2478/tjeb-2018-0010.
[45] A.J. Barenberg, D. Basu, C. Soylu, The effect of public health expenditure on infant mortality: evidence from a panel of Indian states, 1983–1984 to 2011–2012, J. Dev. Stud. 53 (10) (2017) 1765–1784, https://doi.org/10.1080/00220388.2016.1241384.
[46] K. Kumar, F. Ram, A. Singh, Public health spending on infant and child mortality in India during the years 1980–2006, Lancet 381 (2013) S76, https://doi.org/10.1016/S0140-6736(13)61330-6.
[47] World Health Organization (WHO). Child mortality and causes of death, Geneva, Switzerland (2014) Available via http://www.who.int/gho/child_health/mortality/en/. (Accessed 26 May 2020).
[48] A. Martin, D. Lassman, L. Whittle, A. Catlin, T. National Health Expenditure Accounts Team, Recession contributes to slowest annual rate of increase in health spending in five decades, Health Aff. 30 (1) (2011) 11–22, https://doi.org/10.1377/hlthaff.2010.1032.
[49] T.J. Ebob, Cholera prevention and control strategies; A global overview, Journal of Advances in Medicine and Medical Research 32 (12) (2020) 27–53, https://doi.org/10.9734/jammr/2020/v32i1230540.
[50] D. Legros, Global cholera epidemiology: opportunities to reduce the burden of cholera by 2030, J. Infect. Dis. 218 (suppl_3) (2018) S137–S140, https://doi.org/10.1093/infdis/jiy486.
[51] A.I. Khan, A. Levin, D.L. Chao, D. DeRoeck, D.T. Dimitrov, J.A. Khan, F. Qadri, The impact and cost-effectiveness of controlling cholera through the use of oral cholera vaccines in urban Bangladesh: a disease modeling and economic analysis, PLoS Neglected Trop. Dis. 12 (10) (2018) e0006652, https://doi.org/10.1371/journal.pntd.0006652.
[52] J. Novignon, S.A. Olakojo, J. Nonvignon, The effects of public and private health care expenditure on health status in sub-Saharan Africa: new evidence from panel data analysis, Health economics review 2 (1) (2012) 22, https://doi.org/10.1186/2191-1991-2-22.
[53] I.P. Sede, I. Nosakhare, Government health expenditure and malaria in Nigeria, YOBE JOURNAL OF ECONOMICS (YOJE) 19 (2018).
[54] R.H. Morrow, A. Kisuule, M.C. Pike, P.G. Smith, Burkitt's lymphoma in the Mengo Districts of Uganda: epidemiologic features and their relationship to malaria, J. Natl. Cancer Inst. 56 (3) (1976) 479–483.