

Pecuniary Value of Disability-Adjusted-Life-Years in the Arab Maghreb Union in 2015

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Abstract

This study bridges extant information gap on the pecuniary value of disability-adjusted-life-years (DALYs) lost in the Arab Maghreb Union (AMU). The DALYs lost in 2015 are converted into money using human capital (lost output) approach. The AMU total value of DALYs lost from all causes is the sum of each of the five country's pecuniary value of DALYs (PVD) lost from all causes. The PVD associated with DALYs lost due to jth disease among persons of a specific age group is the product of the per capita non-health GDP in international dollars (Int\$) and the total DALYs lost. The 27,175,610 DALYs lost in AMU in 2015 had a pecuniary value of Int\$ 289,033,271,814, which is equivalent to 25.6% the sub-region's 2015 GDP. The average pecuniary value per DALY lost was Int\$ 10,636, which ranged from a minimum of Int\$ 4226 in Mauritania to a maximum of Int\$ 13,852 in Algeria. The pecuniary value of DALYs lost from all causes in the AMU sub-region annually is substantive.

Keywords

Disability-Adjusted-Life-Year (DALY), Pecuniary Value of DALY, Gross Domestic Product, Arab Maghreb Union

1. Introduction

The Arab Maghreb Union (AMU) consists of five member countries, *i.e.* Algeria, Libya, Mauritania, Morocco and Tunisia. The five countries had a total population of 95.423 million in 2015 [1]. The population was distributed as follow: 42% in Algeria, 7% in Libya, 4% in Mauritania, 36% in Morocco, and 12% in Tunisia. Algeria and Libya are upper-middle income countries; and the remaining three countries are lower-middle income countries.

In 2015, the total gross domestic product (GDP) for AMU was 1,130,611,000,000 International Dollars (Int\$), out of which 53.9% was from Algeria, 8.0% from Libya, 1.5% from Mauritania, 25.0% from Morocco and 11.6% from Tunisia [2]. The per capita GDP was Int\$ 14,532 for Algeria, Int\$ 14,679 for Libya, Int\$ 4311 for Mauritania, Int\$ 8180 for Morocco and Int\$ 11,451 for Tunisia [2].

The life expectancy at birth was 75.6 years in Algeria, 72.7 years in Libya, 63.1 years in Mauritania, 74.3 years in Morocco and 75.3 year in Tunisia [1]. The life expectancies, except for Mauritania, were higher than the average global life expectancy of 71.4 years. The physician and pharmaceutical personnel densities per 10,000 population of AMU countries are lower than the global averages (see **Table 1**) [3] [4]. Likewise, the density of health infrastructure and technologies (e.g. psychiatric beds, radiotherapy units) for AMU are lower than the global averages [3]. The global per capita total expenditure on health is 4-fold than that of AMU countries. The per capita total expenditure on health for AMU countries is between US\$49 and US\$372 [4], which falls short of the US\$ 146 (lower-middle income) to US\$ 536 (upper-middle income) per person per year health systems investment recommended for achieving health sustainable development goal (SDG) 3 [5].

Health System Indicators	Algeria	Libya	Mauritania	Morocco	Tunisia	Global average
Physicians per 10000 population*	12.1	19.0	1.3	6.2	12.2	13.9
Nursing and midwifery personnel per 10,000 population*	19.5	68.0	6.7	8.9	32.8	28.6
Dentistry personnel per 10,000 population*	3.3	6.0	0.3	0.8	2.9	2.8
Pharmaceutical personnel per 10,000 population*	2.4	3.6	0.4	2.7	3.0	4.5
Psychiatrists per 10000 population*	0.2	0.1	-	<0.05	0.3	0.2
Hospitals per 100,000 population*	-	2.6	1		2.3	-
Psychiatric beds per 100,000 population*	10.7	9.6	-	6.3	10.7	22.9
Computed tomography units per million population*	-	9.7	1.5	1.2	8.9	-
Radiotherapy units per million population*	0.4	1.0	0.3	0.4	1.6	1.8
Mammography Units per million population*	-	-	22.4	18.5	22.6	-
Per capita total expenditure on health (US\$) (2014)**	362	372	49	190	305	1025
Per capita total expenditure on health (Int\$) (2014)**	932	806	148	447	785	1173

Table 1. Health systems indicators for Arab Maghreb union member states.

Source: *WHO [3], **WHO [4].

Consequently, there is need for AMU sub-region economic burden of disease estimates for use in sensitization of Ministries of Finance, private sector and development partners to increase health development investments to the levels recommended for achievement of SDG3. Such studies are routinely conducted in economically developed countries to raise public and whole-government awareness of potential economic returns from health development investments [6]-[17]. Economic burden of disease studies has been conducted in Southeast Asia [18]-[23] and West Pacific [24] [25] [26] [27] [28]. Latin America has also recorded conduct of some economic burden of disease studies [29]-[36].

A number of studies in Africa have attempted to estimate the economic burden of premature mortality from neglected tropical diseases [37], childhood diseases [38], cholera [39], diabetes mellitus [40], disasters [41], Ebola Virus Disease [42], HIV/AIDS [43] [44], malaria [45] [46] [47] [48], maternal conditions [49] [50], mental and behavioural disorders [51], non-communicable diseases [52] and tuberculosis [53] [54].

There is a dearth of comprehensive economic burden of disease studies conducted in AMU. Boutayeb *et al.* [55] estimated direct cost of diabetes in Morocco to be between US \$0.47 and US \$1.5 billion and the indirect cost to be US\$2 billion. Croitoru and Sarraf [56] estimated that premature mortality caused by air pollution costs Morocco society about US\$1.14 billion annually (1.05 percent of the country's GDP). Majorowski *et al.* [57] estimated that echinococcosis in both humans and animals causes Tunisia direct and indirect losses of around US\$10 - 19 million yearly. Bouame *et al.* [58] estimated the economic burden of NVAF non-valvular atrial fibrillation in Algeria at \in 65 million annually. We did not find any economic burden of disease study conducted in Libya and Mauritania. No study has attempted to estimate the economic burden of disease of a wide range of diseases in AMU. Also no study has attempted to estimate the value of disability-adjusted-life-years (DALY) lost in AMU. Fox-Rushby and Hanson [59] defined a DALY as:

"the sum of the present value of future years of life time lost through premature mortality, and the present value of years of future life time adjusted for the average severity (frequency and intensity) of any mental or physical disability caused by a disease or injury (p. 326)."

This study contributes to bridging the existing knowledge gap on the pecuniary value of DALYs lost in the AMU in 2015. This paper answers the question: What is the total pecuniary value of DALYs lost from all causes in the AMU? The specific objective was to estimate the total pecuniary value of DALYs lost from all causes in the AMU in 2015.

2. Methods

2.1. Study Area and Population

The study focuses on DALYs lost from all causes amongst seven age groups in AMU in 2015. The causes comprise all communicable diseases, maternal condi-

tions, neonatal conditions and nutritional deficiencies; all non-communicable diseases (NCDs), covering malignant neoplasms, mental and substance-use disorders, neurological conditions, sense-organ diseases, cardiovascular diseases, respiratory diseases, digestive diseases, genitourinary diseases, musculoskeletal diseases, congenital anomalies, oral conditions and sudden infant death; and intentional and unintentional injuries [60].

2.2. Study Design

2.2.1. The Lost Output or Human Capital Approach

We applied lost output or human capital approach (HCA) to convert the DALYs lost in AMU in 2015 into their pecuniary equivalents. The HCA theoretical foundations have been documented in past studies [61] [62]. Our choice of HCA was influenced by successful applications in other continents [6] [7] [11] [12] [19] [29] [49] and availability of data on GDP per capita, total health expenditure per capita and DALYs for AMU. GDP of any country consists of four components: personal consumption expenditures, investment, government expenditure and net exports. The AMU GDP per capita equals total expenditure divided by total population. The methods of calculating DALY are contained in Murray [63] and WHO [60]. We hypothesis that DALY losses erode incomes and consumption of households and firms, savings and investment, taxes and service fees, and net exports.

The AMU total pecuniary value of total DALYs (TPVD) lost from all causes is the sum of each of the five country's pecuniary value of DALYs (CPVD) lost from all causes:

$$TPVD_{i} = \sum_{\text{country}=1}^{\text{country}=5} \{CPVD_{i}\}$$
(1)

where *j* = Algeria, Libya, Mauritania, Morocco and Tunisia.

Each country's pecuniary value of DALYs (CPVD) lost due to the jth disease is the sum of CPVD among people aged 0 - 4 years (CPVD₀₋₄), 5 - 14 years (CPVD₅₋₁₄), 15 - 29 years 15 - 29 years (CPVD₁₅₋₂₉), 30 - 49 years (CPVD₃₀₋₄₉), 50 - 59 years (CPVD₅₀₋₅₉), 60 - 69 years (CPVD₆₀₋₆₉), and 70 years and above (CPVD_{=>70}). The CPVD associated with the jth disease DALYs lost among people of a specific age group are the product of the per capita non-health GDP in purchasing power parity (PPP) and the total jth disease DALYs lost within a specific age group [64].

Each *t*th country's discounted total CPVD attributable to the *j*th disease DALYs were estimated using equations (2) through (9) below [64].

$$\sum_{0-4}^{\geq 70} \left(\text{CPVD}_{0-4} + \text{CPVD}_{5-14} + \text{CPVD}_{15-29} + \dots + \text{CPVD}_{\geq 70} \right)$$
(2)

$$CPVD_{0-4} = \left[NHGDPPC_{Int\$} \right] \times \left[DALY_{0-4} \right]$$
(3)

$$CPVD_{5-14} = \left[NHGDPPC_{Int\$} \right] \times \left[DALY_{5-14} \right]$$
(4)

$$CPVD_{15-29} = \left[NHGDPPC_{Int\$} \right] \times \left[DALY_{15-29} \right]$$
(5)

$$CPVD_{30-49} = \left[NHGDPPC_{Int\$} \right] \times \left[DALY_{30-49} \right]$$
(6)

$$CPVD_{50-59} = \left\lceil NHGDPPC_{Int\$} \right\rceil \times \left\lceil DALY_{50-59} \right\rceil$$
(7)

$$CPVD_{60-69} = \left\lceil NHGDPPC_{Int\$} \right\rceil \times \left\lceil DALY_{60-69} \right\rceil$$
(8)

$$CPVD_{\geq 70} = \left[NHGDPPC_{Int\$} \right] \times \left[DALY_{\geq 70} \right]$$
(9)

where: NHGDPPC_{Ints} is the per capita non-health GDP in purchasing power parity (PPP), which was obtained by subtracting the per capita total health expenditure (PCTHE) from the per capita GDP (GDPPC_{Ints}); DALY₀₋₄ is the total DALYs lost to the jth disease from age 0 - 4 years in country *i* in 2015; DALY₅₋₁₄ is the total DALYs lost to the jth disease from age 5 - 14 years in country *i* in 2015; DALY₁₅₋₂₉ is the total DALYs lost to the jth disease from age 15 - 29 years in country *i* in 2015; DALY₃₀₋₄₉ is the total DALYs lost to the jth disease from age 30 - 49 years in country *i* in 2015; DALY₅₀₋₅₉ is the total DALYs lost to the jth disease from age 50 - 59 years in country *i* in 2015; DALY₆₀₋₆₉ is the total DALYs lost to the jth disease from age 60 - 69 years in country *i* in 2015; and DALY₇₀₊ is the total DALYs lost to the jth disease from age 70 years and above in country *i* in 2015.

The DALY estimates published by the WHO in the Global Health Observatory are discounted at a 3% rate [64]. Therefore, we did not introduce a discount factor in equations (3) to (9) to avoid double discounting.

2.2.2. Estimation of the Reductions in Pecuniary Value of DALY Losses in AMU Assuming SDG 3 Related Targets Are Achieved

Table 2 reproduces the United Nations Sustainable Development Goal 3 targets.

Target	Description
SDG 3.1	By 2030, reduce the global maternal mortality ratio to less than 70 per 100,000 live births [65].
SDG 3.2	By 2030, end the preventable deaths of newborns and children under 5 years of age and reduce neonatal mortality to 12 per 1000 live births or lower and under-5 mortality to 25 per 1000 live births or lower in all countries [65].
	By 2030, end the epidemics of AIDS, tuberculosis, malaria and neglected tropical diseases and reduce hepatitis, water-borne diseases and other communicable diseases [65].
SDG 3.3	(a). HIV-related deaths will be reduced to fewer than reduce global HIV-related deaths to below 500,000 [66] in 2020 from a 2015 baseline of 1,062,352 [67], <i>i.e.</i> a target reduction of 52.93%.
	(b). Malaria mortality rates will be reduced globally by at least 90% from 2015 to 2030 [68].
	The number of TB deaths will be reduced by 90% from 2015 to 2030 [69].
	Mortality due to vector-borne diseases will be reduced globally by at least 75% from 2016 to 2030 [70].
SDG 3.4	By 2030, reduce premature mortality due to NCDs by one third through prevention and treatment and promote mental health and well-being [65].
SDG 3.6	By 2020, halve the number of global deaths and injuries due to traffic accidents [65].

Table 2. United Nations sustainable development goal 3 targets.

Sources: Targets in **Table 2** were obtained from UN [65], WHO [66], WHO [67], WHO [68], WHO [69] and WHO [70].

The reductions in AMU pecuniary values of DALYs lost assuming the SDG3 targets for maternal mortality ratio (Target 3.1), neonatal mortality (Target 3.2), children under 5 years of age mortality (Target 3.2), and HIV/AIDS deaths (Target 3.3) are achieved were estimated using the following formula:

$$PVD_{HCj2030} = \sum_{Country=1}^{Country=5} \left\{ PVD_{HCj2015} - \left[PVD_{HCj2015} \times \frac{HCj2015 - SDG_{jHCT}}{HCj2015} \right] \right\}$$

where: $PVD_{HCj2030}$ is the total pecuniary value of DALYs expected to be lost in AMU from jth health condition in 2030 assuming related target is fully achieved; $PVD_{HCj2015}$ is the total pecuniary value of DALYs actually in AMU from jth health condition in baseline year 2015; and SDG_{jHCT} is the SDG jth health condition target mortality rate.

The reductions in AMU pecuniary values of DALYs lost assuming the SDG3 targets for death associated with tuberculosis (Target 3.3), malaria (Target 3.3), neglected tropical diseases (NTD) (Target 3.3), NCD (Target 3.4), and injuries (Target 3.6) are attained were estimated using the following formula:

$$PVD_{HCj2030} = \sum_{Country=1}^{Country=5} \left\{ PVD_{HCj2015} - \left[PVD_{HCj2015} \times SDG_{jHCT} \right] \right\}$$

The detailed elucidation of those algorithms can be found in Kirigia and Mwabu [64] study on monetary value of DALYs lost in the East African Community.

2.3. Data Source and Software

The nine equations in subsection 2.2 were estimated using per capita total health expenditure data from the WHO Global Health Expenditure Database [4], per capita GDP data from the International Monetary Fund World Economic Outlook database [2], and DALYs data from the WHO Global Health Observatory [67]. The nine equations were estimated using Excel Software developed by Microsoft (New York).

3. Results and Discussion

3.1. Estimates of Pecuniary Value of DALYs Lost in the AMU in 2015 without SDGs

In 2015, the AMU lost a total of 27,175,610 disability-adjusted-life years (DA-LYs) from all causes. Out of the total DALY loss, 40% was borne by Algeria, 6% by Libya, 8% by Mauritania, 35% by Morocco, and 11% by Tunisia (**Table 3**).

The DALY losses in the AMU translated into a total pecuniary value loss of Int\$ 289,033,271,814; which is equivalent to 25.6% of the region's 2015 GDP. Out of which, 52% was borne by Algeria, 8% by Libya, 3% by Mauritania, 26% by Morocco, and 11% by Tunisia.

The average pecuniary value per DALY lost was Int\$ 10,636; which ranged from a minimum of Int 4226 in Mauritania to a maximum of Int\$ 13,852 in Algeria. Whilst, the average pecuniary value per person in population was Int\$ 3022; and varied between Int\$ 2199 in Morocco and Int\$3,755 in Algeria.

Country	DALYS in 2015*	Total Pecuniary Value of DALY (Int\$)**	Pecuniary Value per person in population (Int\$)**	Pecuniary Value per DALY (Int\$)**
Algeria	10,751,511	148,931,121,416	3755	13,852
Libya	1,657,484	22,550,405,460	3592	13,605
Mauritania	2,148,766	9,081,592,955	2232	4226
Morocco	9,601,464	75,605,976,582	2199	7874
Tunisia	3,016,385	32,864,175,401	2920	10,895
TOTAL	27,175,610	289,033,271,814	3022	10,636

Table 3. Pecuniary value of DALYs lost from all causes in Arab Maghreb Union countries(Int\$ or PPP, in 2015).

Source: *Statistics from WHO [67]. **Results from authors calculations.

About Int\$ 194,446,261,917 (67.3%) of total AMU pecuniary value of DALYs lost resulted from non-communicable diseases (NCD); Int\$ 63,387,210,534 (21.9%) from communicable, maternal, perinatal and nutrition conditions (CMN); and Int\$ 31,199,799,363 (10.8%) from injuries.

Nearly 24.3% of the pecuniary value of NCD DALY loss resulted from cardiovascular diseases; 12.3% from mental and substance use disorders; 11.8% from malignant neoplasms; 9% from diabetes mellitus; 8.0% from musculoskeletal diseases; 6.9% from neurological conditions; 5.6% from congenital anomalies; 4.8% from genitourinary diseases; 4.7% from sense organ diseases; 3.9% from digestive diseases; 3.8% from respiratory diseases; 1.6% from skin diseases; 1.6% from endocrine, blood, immune disorders; 1.3% from oral conditions; 0.5% from other neoplasms; and 0.1% from sudden infant death syndrome (**Figure 1**).

Cardiovascular diseases, mental and substance use disorders, malignant neoplasms, diabetes mellitus, and musculoskeletal diseases alone accounted for 65.3% of the total pecuniary value of DALYs lost in the AMU.

Approximately 43.8% of the pecuniary value of CMN DALY loss was from neonatal conditions (preterm birth complications, birth asphyxia and birth trauma, neonatal sepsis and infections, and other neonatal conditions); 23.4% from infectious and parasitic diseases; 20.1% from respiratory infectious diseases (lower respiratory infections, upper respiratory infections, and otitis media); 10.3% from nutritional deficiencies (e.g. protein-energy malnutrition, iodine deficiency, vitamin A deficiency, iron-deficiency anaemia, and other nutritional deficiencies); and 2.3% from maternal conditions (Figure 2).

Neonatal conditions, respiratory infectious diseases and nutritional deficiencies are responsible for 74.3% of CMN pecuniary losses.

Almost 82% of the pecuniary value of injury-related DALY loss stemmed from unintentional injuries and 18% from intentional injuries. The three leading causes of pecuniary value of DALYs lost from intentional injuries were road injuries (46.8%), falls (9.7%) and exposure to mechanical forces (6.3%) (**Figure 3**).



Figure 1. Pecuniary value of DALYs lost from communicable, maternal, perinatal and nutritional conditions in Arab Maghreb Union (Int\$ or PPP) Source: Authors estimates.



10,000,000,000 20,000,000,000 30,000,000,000 40,000,000,000 50,000,000,000 International Dollars (Int\$)

Figure 2. Pecuniary value of DALYs lost from non-communicable diseases in Arab Maghreb Union (Int\$ or PPP) Source: Authors estimates.



Figure 3. Pecuniary value of DALYs lost from injuries in Arab Maghreb Union (2015 Int\$ or PPP) Source: Authors estimates.

Majority of the unintentional injuries pecuniary value of Int\$ 5,621,933,544 was from self-harm (35.7%) and interpersonal violence (35.1%).

3.2. Pecuniary Value of DALY Losses from Five SDG 3 Related Targets

Approximately Int\$ 240,663,156,194 (83.3%) of the total pecuniary value of DALYs lost in AMU in 2015 resulted from the SDG3 health conditions listed in **Table 2. Table 4** shows the distribution of pecuniary value of DALYs lost in AMU from SDG3 related health conditions and diseases.

The NCDs accounted for about 81% of the pecuniary value of DALYs lost from SDG-related health conditions. The neonatal conditions and road injuries account for approximately 12% and 5% respectively. Maternal conditions, tuberculosis, HIV/AIDS, malaria and NTDs are not significant causes of pecuniary value of DALY losses in the AMU. The pecuniary value of DALYs lost from all the causes of illness in AMU are in **Appendix I**.

3.3. Estimates of Reductions in Pecuniary Value of DALY Losses in AMU if the Five SDG 3 Related Targets Are Achieved

As shown in **Table 5**, if all the five SDG3 targets in **Table 2** are fully achieved, the SDG3-related pecuniary value of DALYs lost would be reduced by Int\$ 83,133,147,743 (34.5%).

	Pecuniary value of DALYs lost (Int\$ or PPP)*	Percent**
SDG 3.1: Maternal conditions	1,472,716,293	0.6
SDG 3.2: Neonatal conditions	27,787,753,001	11.5
SDG 3.3: Tuberculosis	3,070,236,330	1.3
SDG 3.3: HIV/AIDS	802,739,773	0.3
SDG 3.3: Malaria	314,945,331	0.1
SDG 3.3: NTDs	810,565,995	0.3
African Trypanosomiasis	-	
Chagas disease	-	
Schistosomiasis	529,818,130	
Leishmaniasis	85,085,646	
Lymphatic filariasis	-	
Onchocerciasis	-	
Cysticercosis	11,177,763	
Echinococcosis	39,937,490	
Dengue	489,790	
Trachoma	47,837,646	
Rabies	64,682,524	
Ascariasis	21,878,148	
Trichuriasis	1,731,645	
Hookworm disease	4,515,719	
Food-borne trematodes	-	
Leprosy	3,411,492	
DG 3.4: Non-communicable diseases	194,446,261,917	80.8
Malignant neoplasms	22,894,672,397	
Other neoplasms	897,484,434	
Diabetes mellitus	17,544,290,025	
Endocrine, blood, immune disorders	3,141,123,979	
Mental and substance use disorders	23,947,083,831	
Neurological conditions	13,321,140,090	
Sense organ diseases	9,045,718,187	
Cardiovascular diseases	47,192,566,894	
Respiratory diseases	7,478,562,499	
Digestive diseases	7,570,814,258	
Genitourinary diseases	9,303,205,193	
Skin diseases	3,050,806,679	
Musculoskeletal diseases	15,489,913,366	
Congenital anomalies	10,865,434,057	
Oral conditions	2,551,725,489	
Sudden infant death syndrome	151,720,539	
SDG 3.6: Road injury	11,957,937,553	5.0
TOTAL (INT\$)	240.663.156 194	100.0

Table 4. AMU pecuniary value distributed by SDG health conditions (2015 Int\$).

Sources: *Pecuniary value of DALYs lost (Int\$ or PPP) and **Percent are authors estimates.

Target	Description	Percentage reduction envisaged in SDG targets*	Reduction in pecuniary value of DALYs lost (Int\$)**
SDG 3.1	By 2030, reduce the global maternal mortality ratio to less than 70 per 100,000 live births [65].	62.5%	920,841,879
SDG 3.2	By 2030, end preventable deaths of newborns, with all countries aiming to reduce neonatal mortality to at least as low as 12 per 1,000 live births [65].	26.4	7,330,511,528
	By 2030, end the epidemics of AIDS, tuberculosis, malaria and neglected tropical diseases and reduce hepatitis, water-borne diseases and other communicable diseases [65].		
SDG 3.3	(a). Reduce global HIV-related deaths from 1,062,352 in 2015 to below 500,000 by 2020 [66].	52.93%	424,890,162
	(b). Malaria mortality rates will be reduced globally by at least 90% from 2015 to 2030 [68].	90%	283,450,798
	The number of TB deaths will be reduced by 90% from 2015 to 2030 [69]	90%	2,763,212,697
	Mortality due to vector-borne diseases will be reduced globally by at least 75% from 2016 to 2030 [70].	75%	615,857,745
SDG 3.4	By 2030, reduce premature mortality due to NCDs by one third through prevention and treatment and promote mental health and well-being [65].	33.3%	64,815,414,157
SDG 3.6	By 2020, halve the number of global deaths and injuries from road traffic accidents [65].	50%	5,978,968,777
	TOTAL		83,133,147,743

Table 5. Estimate of reduction in pecuniary value of DALY losses if the five SDG3 targets are achieved.

Sources:*Percentage reductions envisaged in SDG targets were obtained from UN [65], WHO [66], WHO [67], WHO [68], WHO [69] and WHO [70]. **Reductions in pecuniary value of DALYs lost (Int\$) are authors estimates.

3.3.1. SDG Target 3.1: Maternal Health Conditions

The AMU lost DALYs worth Int\$ 1,472,716,293 in 2015 from maternal conditions. However, if SDG target 3.1 is fully achieved, the pecuniary value of DALY losses in 2030 would be Int\$ 551,874,414. This implies a saving of Int\$ 920,841,879 per year. The reduction in maternal conditions related pecuniary losses may be realized if AMU states implement the UN Commission on the Status of Women resolution that calls upon Government authorities and international leaders at all levels to generate requisite political will, increased resources, commitment, international cooperation and technical assistance to strengthen health systems with a view to guaranteeing all women and girls universal access to comprehensive health services to decrease maternal mortality and morbidity, and improve maternal and new born health [71].

All such efforts should be guided by the UN Human Rights Council resolution A/HRC/RES/33/18 that urges States and encourages other relevant stakeholders to take action at all levels, utilizing a human rights-based approach to address the interlinked causes of maternal mortality and morbidity, such as inaccessibility to affordable and appropriate health-care services, lack of information and education, poverty, food insecurity, harmful cultural practices (including child

marriage, wife inheritance, female genital mutilation), early childbearing, gender inequalities, discrimination and domestic violence against women [72].

3.3.2. SDG 3.2: Neonatal Health Conditions

The preterm birth complications, birth asphyxia and birth trauma, neonatal sepsis and infections, and other neonatal conditions led to a loss of DALYs valued at Int\$ 27,787,753,001 in 2015. If SDG target 3.2 is fully attained, the pecuniary value of DALYs lost in 2030 would be Int\$ 20,457,241,473, which denotes a saving of Int\$ 7,330,511,528 per year. The saving can be made by adapting and implementing the African Union Maputo plan of action 2016-2030, which contains nine strategic areas of focus and priority interventions (plus indicators for monitoring progress) for assuring realization of sexual and reproductive health and rights, and ultimately, improve maternal, newborn, child and adolescent health [73].

3.3.3. SDG Target 3.3: HIV/AIDs, Tuberculosis, Malaria and Neglected Tropical Diseases

In 2015, the AMU lost DALYs valued at Int\$ 802,739,773 from HIV/AIDS; Int\$ 3,070,236,330 from tuberculosis; Int\$ 314,945,331 from malaria; and Int\$ 821,143,660 from neglected tropical diseases (NTD). If SDG 3.3 is realized, the pecuniary value of DALYs lost in 2030 from HIV/AIDS would Int\$ 377,849,611; from TB would be Int\$ 307,023,633; from malaria would be Int\$ 31,494,533; and from NTD would be Int\$ 205,285,915. Therefore, achievement of SDG3.3 would save Int\$ 424,890,162 from HIV/AIDS; Int\$ 2,763,212,697 from TB; Int\$ 283,450,798 from malaria; and Int\$ 615,857,745 from reduced NTD burden. The AMU States might realize those savings if they fully implement their past commitments contained in the relevant United Nations General Assembly Resolutions.

First, the commitments agreed in the political declaration on HIV and AIDS, which calls for increasing and front-loading investments from domestic and external sources, and promote laws, policies and practices for ensuring universal access to high-quality, affordable and comprehensive sexual and reproductive health-care and HIV services, information and commodities with a view to ending the AIDS epidemic by 2030 [74] [75].

Second, the commitments encapsulated in the political declaration on antimicrobial resistance, which urges member states to develop and adequately fund multi-sectoral One Health national policies, programmes and action plans to combat resistance of bacterial, viral, parasitic and fungal microorganisms to antimicrobial medicines [76].

Third, on 26 September 2018 UNGA adopted a political declaration on the fight against tuberculosis entitled "United to End Tuberculosis: An Urgent Global Response to a Global Epidemic". In that political declaration member states committed to provide diagnosis and treatment; address tuberculosis prevention, diagnosis, treatment and care in the context of child health and survival; prevent tuberculosis for those most at risk of falling ill through the rapid scale-up of access to testing for tuberculosis infection; develop national antim-

icrobial resistance strategies, capacities and plans; find the missing people with tuberculosis; systematically screen relevant risk groups; adapt and implement rapidly the global End TB Strategy; develop community-based health services; explore how digital technologies could be optimally used for effective tuberculosis prevention, treatment and care; pursue multi-sectoral collaboration at all levels; foster cooperation between public and private sector entities; create an environment conducive to research and development of new tools for tuberculosis; mobilize sufficient and sustainable financing, from all sources, for universal access to quality prevention, diagnosis, treatment, and care of tuberculosis [77].

Fourth, the UNGA resolution A/RES/72/309 calls upon countries, multilateral and bilateral development partners to substantially increase funding to countries to provide universal access to existing life-saving tools for the prevention, diagnosis and treatment of malaria [78].

Lastly, the UN Commission on Population and Development resolution 2010/1 encourages Member States and international organizations to scale up actions aimed at ensuring universal access to prevention and treatment of neglected tropical diseases, and access to affordable safe water and sanitation [79]. In the London declaration on NTDs, pharmaceutical companies and international development partners committed to sustain, expand and extend drug access programmes to ensure the necessary supply of drugs and other interventions to help end NTD epidemic [80].

3.3.4. SDG Target 3.4: Non-Communicable Diseases

In 2015, the AMU lost NCD-related DALYs with a pecuniary value of Int\$ 194,446,261,917. If SDG target 3.4 is fully attained, the pecuniary value of DALYs lost in 2030 would be Int\$ 129,630,847,759, which denotes a saving of Int\$ 64,815,414,157 per year. The AMU may actualize such a saving if member states implemented fully the commitments contained in their political declaration on the Prevention and Control of Non-communicable Diseases, which calls for development of multi-sectoral policies to reduce risk factors and create health-promoting environments; strengthening of national health systems; strengthening international cooperation in support of development and implementation national plans for the prevention and control of NCDs; increasing national and international investments to strengthen national capacity for research and development; and reinforcing of country-level surveillance and monitoring systems [81].

3.3.5. SDG Target 3.6: Road Traffic Injuries

In 2015, the AMU lost road injury-related DALYs with a pecuniary value of Int\$ 11,957,937,553. If SDG target 3.6 is fully attained, the pecuniary value of DALYs lost in 2030 would be Int\$ 5,978,968,777, which denotes a saving of Int\$ 5,978,968,777 per year. The AMU might make such a saving if member states were to fully implement the UNGA resolutions A/RES/57/309 and A/RES/72/271 that encourages governments to promulgate and enforce existing

traffic laws; and to raise awareness of the widespread problem of preventable road traffic deaths and injuries through information, communication and education [82] [83].

4. Conclusions

The study has successfully estimated pecuniary value of DALYs lost in the AMU in 2015, and reductions in pecuniary value of DALY losses if five SDG3 targets are achieved. The findings from this study could potentially be used by health development stakeholders to advocate for increased domestic and external investments towards achievement of SDG3.

The non-communicable and communicable diseases, and injuries resulted in a significant number of DALY losses valued at Int\$ 289 billion in the AMU. Approximately 83% of the total pecuniary value of DALYs lost in AMU is from SDG-related health conditions. Full attainment of the five CDS, NCD and injuries-related SDG3 targets would reduce the total pecuniary value of DALYs lost 35% in AMU.

In order to significantly reduce the SDG3-related DALY losses, the AMU countries should intensify their whole-of-government and whole-of-society efforts to fully implement their past health-related commitments contained in UNGA [71] [72] [74]-[79] [81] [82] [83] and African Union [73] declarations and resolutions.

Universal access to health services will not be sufficient for AMU States to attain the health SDG3 of ensuring healthy lives and promoting well-being for people at all ages. There is need for simultaneous policy actions to revamp systems that address other-related SDGs, such as SDG1 on ending poverty in all its forms, SDG2 on ending hunger through food security, SDG4 on equitable education and lifelong learning, SDG 5 on gender equality, SDG 6 on availability and sustainable management of water and sanitation, SDG 11 on inclusive, safe, resilient and sustainable human shelter (housing), SDG 13 on combating negative health impacts of climate change, and SDG 16 on promoting peaceful and inclusive societies [65]. This will require strong and efficiently coordinated collaboration across multiple sectors in individual member states. Cultivation and nurturing of solidarity and closer cooperation and partnership between the AMU States is bound to accelerate the progress towards attainment of SDG3 and other related SDGs. Significant reductions in burden of disease will have substantive social and economic impact on AMU. All along the AMU States (public and private sector leaders) and development partners should always remember that health is wealth of AMU.

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Conflicts of Interest

The authors declare no conflicts of interest regarding the publication of this paper.

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Appendix I

AMU pecuniary value distributed by diseases.

Diseases/Health Conditions	Pecuniary Value of DALYs lost (2015 Int\$ or PPP)*
All Causes (I + II + III)	289,033,271,814
(I) Communicable, maternal, perinatal and nutritional conditions $(A + B + C + D + E)$	63,387,210,534
(A) Infectious and parasitic diseases (1 + 2 + 3 + + 12)	14,809,699,743
1) Tuberculosis	3,070,236,330
2) STDs excluding HIV $(a + b + c + d + e + f)$	1,625,540,786
a) Syphilis	626,251,524
b) Chlamydia	89,530,563
c) Gonorrhoea	792,881,227
d) Trichomoniasis	19,867,075
e) Genital herpes	28,502,609
f) Other STDs	68,507,787
3) HIV/AIDS	802,739,773
4) Diarrhoeal diseases	4,095,900,271
5) Childhood-cluster diseases $(a + b + c + d)$	669,366,785
a) Whooping cough	425,812,718
b) Diphtheria	1,936,888
c) Measles	94,961,694
d) Tetanus	146,655,485
6) Meningitis	1,136,589,082
7) Encephalitis	577,140,466
8) Hepatitis $(a + b + c + d)$	491,533,443
a) Acute hepatitis A	75,654,965
b) Acute hepatitis B	324,016,032
c) Acute hepatitis C	9,571,914
d) Acute hepatitis E	82,290,532
9) Parasitic and vector diseases $(a + b + c + + m)$	1,104,551,986
a) Malaria	314,945,331
b) African Trypanosomiasis	-
c) Chagas disease	-
d) Schistosomiasis	529,818,130
e) Leishmaniasis	85,085,646
f) Lymphatic filariasis	-
g) Onchocerciasis	-

h) Cysticercosis	11,177,763
i) Echinococcosis	39,937,490
j) Dengue	489,790
k) Trachoma	47,837,646
l) Yellow fever	10,577,664
m) Rabies	64,682,524
10) Intestinal nematode infections $(a + b + c + d)$	28,125,512
a) Ascariasis	21,878,148
b) Trichuriasis	1,731,645
c) Hookworm disease	4,515,719
d) Food-borne trematodes	-
11) Leprosy	3,411,492
12) Other infectious diseases	1,204,563,816
(B) <i>Respiratory Infectious</i> (1 + 2 + 3)	12,768,958,306
1) Lower respiratory infections	11,868,674,894
2) Upper respiratory infections	411,325,501
3) Otitis media	488,957,910
(C) Maternal conditions	1,472,716,293
(D) Neonatal conditions $(1 + 2 + 3 + 4)$	27,787,753,001
1) Preterm birth complications	12,863,516,812
2) Birth asphyxia and birth trauma	7,788,404,419
3) Neonatal sepsis and infections	4,788,209,607
4) Other neonatal conditions	2,347,622,163
(E) Nutritional deficiencies $(1 + 2 + 3 + 4 + 5)$	6,548,083,191
1) Protein-energy malnutrition	1,157,040,012
2) Iodine deficiency	465,550,380
3) Vitamin A deficiency	50,864,035
4) Iron-deficiency anaemia	4,801,459,713
5) Other nutritional deficiencies	73,169,052
(II) Noncommunicable diseases (A + B + + P)	194,446,261,917
(A) <i>Malignant neoplasms</i> (1 + 2 + 3 + + 24)	22,894,672,397
1) Mouth and oropharynx cancers (a + b + c)	855,932,789
a) Lip and oral cavity	194,950,334
b) Nasopharynx	531,348,128
c) Other pharynx	129,634,327
2) Oesophagus cancer	195,906,857
3) Stomach cancer	1,207,976,160
4) Colon and rectum cancers	1,935,255,879

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5) Liver cancer $(a + b + c + d)$	433,845,232
a) Liver cancer secondary to hepatitis B	156,715,485
b) Liver cancer secondary to hepatitis C	172,860,632
c) Liver cancer secondary to alcohol use	56,236,348
d) Other liver cancer	48,032,767
6) Pancreas cancer	522,483,156
7) Trachea, bronchus, lung cancers	2,960,905,851
8) Melanoma and other skin cancers (a + b)	154,115,139
a) Malignant skin melanoma	55,850,959
b) Non-melanoma skin cancer	98,264,180
9) Breast cancer	3,157,446,478
10) Cervix uteri cancer	668,446,851
11) Corpus uteri cancer	85,735,228
12) Ovary cancer	534,967,291
13) Prostate cancer	570,432,436
14) Testicular cancer	63,940,930
15) Kidney cancer	465,095,805
16) Bladder cancer	626,333,082
17) Brain and nervous system cancers	1,135,054,537
18) Gallbladder and biliary tract cancer	537,315,885
19) Larynx cancer	297,671,696
20) Thyroid cancer	290,949,234
21) Mesothelioma	40,925,477
22) Lymphomas, multiple myeloma (a + b + c)	1,815,703,029
a) Hodgkin lymphoma	432,192,940
b) Non-Hodgkin lymphoma	1,065,903,943
c) Multiple myeloma	317,606,146
23) Leukaemia	1,390,480,541
24) Other malignant neoplasms	2,947,752,833
(B) Other neoplasms	897,484,434
(C) Diabetes mellitus	17,544,290,025
(D) Endocrine, blood, immune disorders $(1 + 2 + 3 + 4)$	3,141,123,979
1) Thalassaemias	1,103,334,653
2) Sickle cell disorders and trait	297,471.875
3) Other haemoglobinonathies and haemolytic anaemias	659 552 410
4) Other endocrine blood and immune disorders	1 000 745 040
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1) Depressive disorders (a + b)	8,075,106,819
a) Major depressive disorder	6,853,703,478
b) Dysthymia	1,221,403,340
2) Bipolar disorder	1,435,675,424
3) Schizophrenia	1,673,754,579
4) Alcohol use disorders	541,574,030
5) Drug use disorders $(a + b + c + d + e)$	2,907,304,983
a) Opioid use disorders	2,677,989,051
b) Cocaine use disorders	39,435,333
c) Amphetamine use disorders	67,618,195
d) Cannabis use disorders	53,328,852
e) Other drug use disorders	68,933,552
6) Anxiety disorders	4,063,925,683
7) Eating disorders	158,701,888
8) Autism and Asperger syndrome	1,358,459,488
9) Childhood behavioural disorders (a + b)	1,120,422,379
a) Attention deficit/hyperactivity syndrome	85,627,573
b) Conduct disorder	1,034,794,806
10) Idiopathic intellectual disability	1,279,083,185
11) Other mental and behavioural disorders	1,333,075,373
(F) <i>Neurological conditions</i> (1 + 2 + 3 + 4 + 5 + 6 + 7)	13,321,140,090
1) Alzheimer disease and other dementias	5,280,279,742
2) Parkinson disease	169,109,646
3) Epilepsy	2,184,074,610
4) Multiple sclerosis	117,847,925
5) Migraine	4,322,831,137
6) Non-migraine headache	762,757,196
7) Other neurological conditions	484,239,834
(G) Sense organ diseases (1 + 2 + 3 + 4 + 5 + 6 + 7)	9,045,718,187
1) Glaucoma	489,345,024
2) Cataracts	1,204,258,305
3) Uncorrected refractive errors	1,938,913,441
4) Macular degeneration	543,647,718
5) Other vision loss	1,956,380,584
6) Other hearing loss	2,083,165,081
7) Other sense organ disorders	830,008,034
(H) Cardiovascular diseases $(1 + 2 + 3 + 4 + 5 + 6)$	47,192,566,894
1) Rheumatic heart disease	763,959,288

2) Hypertensive heart disease	1,985,038,973
3) Ischaemic heart disease	21,875,601,292
4) Stroke (a + b)	14,483,823,322
a) Ischaemic stroke	6,804,584,359
b) Haemorrhagic stroke	7,679,238,963
5) Cardiomyopathy, myocarditis, endocarditis	2,958,081,804
6) Other circulatory diseases	5,126,062,214
(I) Respiratory diseases (1 + 2 + 3)	7,478,562,499
1) Chronic obstructive pulmonary disease	2,660,834,451
2) Asthma	4,033,444,409
3) Other respiratory diseases	784,283,639
(J) Digestive diseases (1 + 2 + 3 + 4 + 5 + 6 + 7 + 8 + 9)	7,570,814,258
1) Peptic ulcer disease	590,716,528
2) Cirrhosis of the liver $(a + b + c + d)$	2,752,519,103
a) Cirrhosis due to hepatitis B	889,631,438
b) Cirrhosis due to hepatitis C	1,068,376,630
c) Cirrhosis due to alcohol use	171,346,306
d) Other liver cirrhosis	623,164,727
3) Appendicitis	217,470,049
4) Gastritis and duodenitis	370,142,876
5) Paralytic ileus and intestinal obstruction	1,437,304,855
6) Inflammatory bowel disease	592,386,677
7) Gallbladder and biliary diseases	316,085,659
8) Pancreatitis	287,609,722
9) Other digestive diseases	1,006,578,790
(K) Genitourinary diseases	9,303,205,193
1) Kidney diseases (a + b + c)	6,291,986,731
a) Acute glomerulonephritis	7,498,654
b) Chronic kidney disease due to diabetes	1,645,865,814
c) Other chronic kidney disease	4,638,622,264
2) Benign prostatic hyperplasia	467,745,620
3) Urolithiasis	19,869,318
4) Other urinary diseases	646,727,356
5) Infertility	444,989,468
6) Gynaecological diseases	1,431,886,699
(L) <i>Skin diseases</i>	3,050,806,679
(M) Musculoskeletal diseases	15,489,913,366
1) Rheumatoid arthritis	652,664,479

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2) Osteoarthritis	1,711,917,960
3) Gout	144,950,602
4) Back and neck pain	7,558,236,125
5) Other musculoskeletal disorders	5,422,144,201
(N) <i>Congenital anomalies</i> (1 + 2 + 3 + 4 + 5 + 6)	10,865,434,057
1) Neural tube defects	1,086,284,184
2) Cleft lip and cleft palate	27,450,395
3) Down syndrome	549,980,405
4) Congenital heart anomalies	3,461,476,026
5) Other chromosomal anomalies	284,955,677
6) Other congenital anomalies	5,455,287,369
(O) Oral conditions $(1 + 2 + 3 + 4)$	2,551,725,489
1) Dental caries	258,535,420
2) Periodontal disease	549,507,205
3) Edentulism	1,200,967,213
4) Other oral disorders	542,715,651
(P) Sudden infant death syndrome	151,720,539
(III) Injuries (A + B)	31,199,799,363
(A) Unintentional injuries (1 + 2 + 3 + 4 + 5 + 6 + 7 + 8)	25,577,865,819
1) Road injury	11,957,937,553
2) Poisonings	721,160,274
3) Falls	2,490,511,620
4) Fire, heat and hot substances	1,533,353,109
5) Drowning	1,299,072,914
6) Exposure to mechanical forces	1,609,982,833
7) Natural disasters	60,973,745
8) Other unintentional injuries	5,904,873,772
(B) Intentional injuries (1 + 2 + 3)	5,621,933,544
1) Self-harm	2,005,208,432
2) Interpersonal violence	1,975,898,954
3) Collective violence and legal intervention	1,640,826,157

Source: *Pecuniary value of DALYs lost (2015 Int\$ or PPP) are authors estimates.