Indirect Cost of Non-Communicable Diseases Deaths in the World Health Organization African Region

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Abstract

Background: In 2012, a total of 9,398,809 deaths from all causes occurred in the WHO African Region; out of which 2,788,381 (29.67%) were due to non-communicable diseases (NCD). The objective of this study was to estimate future gross domestic product (GDP) losses associated with NCD deaths in the African Region for use to advocate for increased investments into prevention and management of NCDs.

Methods: Human capital approach is used to estimate non-health GDP losses associated with NCD deaths. Future non-health GDP losses were discounted at 3%. The analysis was done for three income groups of countries and six age groups. One-way sensitivity analysis at 5% and 10% discount rates was undertaken to assess the impact on expected non-health GDP loss estimates.

Results: The 2,788,381 NCD deaths that occurred in the African Region in 2012 are estimated to have resulted in a total discounted GDP loss of Int$ 61,302,450,005. Out of that total loss, 20.36% was borne by those aged 0-4 years; 12.76% by 5-14 years; 16.64% by 15-29 years; 44.93% by 30-59 years; 2.99% by 60-69 years; and 2.33% by those aged 70 years and above. Thus, those aged between 15 and 59 years bore 61.57% of the GDP losses.

Approximately 47.4%, 33.1% and 19.5% of the total loss was borne by high and upper middle-, lower middle- and low-income countries respectively. The average total non-health GDP loss was Int$ 21,985 per NCD death. The average non-health GDP lost per NCD death was Int$ 54,534 for Group 1, Int$ 21,492 for Group 2 and Int$ 9,096 for Group 3.

Conclusion: Premature NCD deaths are associated with substantive GDP losses in countries of the African Region. Therefore, unless African countries and their development partners bolster their investments to assure universal population coverage of cost-effective promotive, preventive and management interventions for NCDs, prospects of achieving the United Nations General Assembly Sustainable Development Goals (SDG) might be greatly undermined in Africa.

Background

World Health Organization (WHO) estimates that there were a total of 55.9 million deaths worldwide in 2012 [1]. Out of those deaths, 23% resulted from communicable, maternal, perinatal and nutritional conditions; 67.8% from non-communicable diseases (NCD); and 9.2% from injuries. About 53% of the dead were male and 47% were female.

In 2012, a total of 9,398,809 deaths from all causes occurred in the WHO African Region (WHO/AFR); out of which 2,788,381 (29.67%) were due to NCD. The NCD deaths in WHO/AFR resulted from thirteen broad causes, including: cardiovascular diseases (36%), malignant neoplasms (Cancers) (15.3%), digestive diseases (12.5%), diabetes mellitus (6.6%), respiratory diseases (6.6%), congenital anomalies (5.4%), neurological conditions (5%), genitourinary diseases (4.8%), endocrine, blood, and immune disorders (4.2%), skin diseases (1.2%), musculoskeletal diseases (1.1%), mental and behavioural disorders (0.7%), and other neoplasms (0.6%) [1]. Thus, the top five causes accounted for approximately 77.1% of NCD deaths in the WHO/AFR.

Approximately 53.3% of the NCD deaths occurred in six countries, i.e. Nigeria, South Africa, DRC, Ethiopia, Algeria and Tanzania. The number of NCD deaths varied widely from a maximum of 503,559 in Nigeria to a minimum of 1,775 in Cape Verde.

Out of the 2.79 million NCD deaths in the region, 8% were in the age bracket 0-4 years, 5.5% in age bracket 5-14 years, 7.3% in age bracket 15-29 years, 26.4% in bracket group 30-59, 18.5% in age bracket 60-69 years and 34.4% among those aged 70 years and above. Thus, majority of NCD deaths occurred among those aged 70 years and above.

NCD mortality and morbidity is associated with a number of preventable risk factors including: unsafe water and lack of sanitation; use of solid fuels in households; childhood under-nutrition and over-nutrition; raised fasting blood glucose (diabetes); harmful use of alcohol; raised blood pressure (hypertension); obesity related to physical inactivity and unhealthy diet; harmful consumption of alcohol; and use of tobacco [2, 3] **(Table 1)**.

Table 1. Risk factors.

Domains/Facets	WHO African Region		Global	
	Male	Female	Male	Female
Prevalence of raised fasting blood glucose among adults aged ≥ 18 years (%) (2014)	8.7	8.5	9.8	8.6
Prevalence of raised blood pressure among adults aged ≥ 18 years (%) (2014)	29.7	29.5	24.0	20.5
Adults aged ≥18 years who are obese (%) (2014)	5.5	15.2	10.7	15.2
Prevalence of smoking any tobacco product among adults aged ≥15 years (%) (2014)	24.2	2.4	36.1	6.8
Alcohol per capita consumption (≥15 years) (litres of pure alcohol) (2010)	6.0		6.2	

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Domains/Facets	WHO African Region		Global	
	Male	Female	Male	Female
Population using solid fuels (%) (2013)	79		41	
Population using improved drinking-water sources (%) (2013)	66		89	
Population using improved sanitation (%) (2013)	33		64	
Children aged < 5 years - wasted (%) (2014)	10.3		7.7	
Children aged < 5 years- stunted (%) (2014)	39.4		24.5	
Children aged < 5 years- underweight (%) (2014)	24.9		15.0	
Children aged < 5 years- overweight (%) (2014)	6.2		6.3	
Source: WHO [2].				

Efforts to prevent and treat NCDs are being hampered by weak national health systems characterized by low density of health workforce, infrastructure and technologies in the African Region [4]. For example, there are 0.8 hospitals per 100,000 population, 3.4 psychiatric beds per 100,000 population, 0.4 tomography units per million population, 0.1 radiotherapy units per million population, and 7.4 mammography units per million females aged 50-69 years. As shown

Table 2. Density of health workforce in the African Region compared to global averages.

Health workforce	African Region (A)	Global (B)	Difference (B/A)
Physicians per 10,000 population	2.7	13.9	5.1
Midwifery personnel per 10,000 population	12.4	28.6	2.3
Dentistry personnel per 10,000 population	0.5	2.8	5.6
Pharmaceutical personnel per 10,000 population	0.8	4.5	5.6
Psychiatrists per 10,000 population	0.05	0.2	4
Source: WHO [2].			

in **Table 2**, the densities of physicians, midwifery personnel, dentistry personnel, pharmaceutical personnel and psychiatrists are 5.1 times, 2.3 times, 5.6 times, 5.6 times and 4 times lower than the global averages [2]. Thirty-six of the 57 countries in the world with fewer than 2.5 health care professionals (counting only doctors, nurses and midwifes) per 1000 population are in the African Region [5]. The African Region per capita total expenditure on health was US$105 (half from out-of-pocket household spending) compared to a global average of US$ 1,025 in 2012. These low health investments imply need for strong advocacy among ministers of finance, private sector and external partners invest more into building of strong and resilient health systems with requisite capacities for combatting NCDs [6].

According to WHO the rapid rise of NCDs threatens economic and social development as well as the lives and health of millions of people [7]. The increase in prevalence of NCDs is disproportionately seen in poor and disadvantaged populations and is contributing to widening health gaps between and within countries [7, 8].

WHO further states that NCDs are to a great extent preventable through interventions against the major risk factors and their environmental, economic, social and behavioural determinants in the population [7]. Thus, a comprehensive prevention strategy needs to blend synergistically an approach aimed at reducing risk factor (such as tobacco consumption, unhealthy diet and physical inactivity, and their determinants) levels in the population as a whole with one directed at high-risk individuals [9]. According to the World Bank since majority of African countries face critical challenges of increasing incidence and prevalence of NCDs and potentially high treatment and productivity costs (amidst weak national health systems and scarce resources), their NCD control strategies will need to emphasize prevention, alongside cost-effective, fiscally sustainable and targeted treatment [10].

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Economic burden of NCD studies have been conducted in some countries of the WHO Regions of the Africa, Americas, Eastern Mediterranean, Europe, South-East Asia, and Western Pacific. In the Eastern Mediterranean, it was estimated that the total direct and indirect cost of the most common NCDs (diabetes mellitus, cardiovascular diseases, chronic respiratory diseases, neuropsychiatric conditions and malignant neoplasms) for the Gulf Cooperation Council (Bahrain, Kuwait, Oman, Qatar, Saudi Arabia, United Arab Emirates) will be $36.2 billion (3.7 percent of non-oil GDP) in 2013 rising to $67.9 billion (3.8 percent of non-oil GDP) by 2022 [11]. Indirect and direct costs constituted 83.8% and 16.2% of the total loss in 2013.

In the European Region, Suhrcke and colleagues estimated the total production (GDP) loss associated with the reported workdays lost due to NCD illness in the Russian Federation to have been US$ 112.87 billion in 2003 [12]. The authors acknowledged that their estimate did not take into account the impact of NCD-related mortality on reduced productivity.

In South-East Asia, Bloom and colleagues estimated undiscounted total cost of the top five NCDs (cardiovascular disease, cancer, chronic respiratory disease, diabetes, and mental health) will be USD 6.2 trillion (in 2010 USD) in India over the period 2012-2030 [13]. Out of the projected total loss for India, 2.4% was caused by diabetes, 36.5% by cardiovascular disease, 19% respiratory disease, 5% by cancer and 37% by mental health disorders.

In the Western Pacific, Australia's 2008-09 health system expenditure on chronic diseases was Australian Dollars (A$) 7.74 billion for cardiovascular diseases, A$6.38 billion for mental health, $5.67 billion for musculoskeletal conditions, A$4.95 billion for cancer, A$4.59 billion for respiratory conditions, A$3.39 billion for nervous system disorders and A$1.52 billion for diabetes mellitus. These expenditures do not include direct costs borne by patients, family members and friends; and income losses from disability and fatalities [14]. Zheng and colleagues estimated the annual potential coronary heart disease-related productivity loss in Australia to be Australian dollars ($A) 1.79 billion in 2004 [15].

Bloom and colleagues estimated undiscounted total cost of the five main NCDs (cardiovascular disease, cancer, chronic respiratory disease, diabetes, and mental health) to be USD 27.8 trillion for China (in 2010 USD) over the period 2012-2030 [13]. Out of the projected total loss for China, 1.8% resulted from diabetes, 29.6% from cardiovascular diseases, 20.55% from respiratory disease, 14.3% from cancer and 33.9% from mental health.

Bloom et al's macroeconomic simulations estimated that cardiovascular disease, chronic respiratory disease, cancer, diabetes and mental health would cost the world a cumulative output loss of US$ 46.7 trillion over two decades (2011-2030), which represented 75% of global GDP in 2010 (US$ 63 trillion) [16]. Out of the total loss, 3.6% was from diabetes, 33.4% from cardiovascular diseases, 10.3% from chronic respiratory diseases, 17.8% from cancer and 34.9% from mental illness. The study included only five NCDs, did not discount the losses, and did not disaggregate the estimated losses by countries.

Abegunde and colleagues using economic growth model estimated that DRC, Ethiopia, Nigeria and South Africa would incur GDP losses of US$ 0.15 billion, US$0.16 billion, US$ 1.17 billion and US$1.88 billion due to heart disease, stroke, and diabetes mortality between 2006 and 2015 [17]. There is clearly paucity of studies in the African Region that estimate economic burden of all NCDs among all the 47 WHO Member States. The study reported in this paper contributes to bridging that knowledge gap.

This paper attempts to address the question: What is the impact of NCD deaths that occurred in 2012 on future non-health gross domestic product (GDP) in the WHO/AFR? The specific objective of this study was to estimate future GDP losses associated with NCD deaths in the African Region for

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use in advocacy for increased investments in prevention and management of NCDs.

Methods

Human Capital Approach Framework

Human capital approach measures the present value of scientific, technical and indigenous knowledge, skills, innovativeness, good work habits (e.g. ability to adapt to new technologies, hard work and teamwork), entrepreneurship, other capabilities and investments embodied in people (civil servants, farmers, teachers, health workers, scientists, scholars, technicians, businessmen, managers and other contributors to national output), – measured roughly by country's per capita gross domestic product (GDP) – that are lost as a result of premature death from any cause, e.g. NCD [18]. This paper uses a human capital approach to estimate non-health GDP losses associated with NCD deaths in the African Region. GDP is the sum of household consumption, private investment and government expenditures and net exports (exports minus imports).

Consumption consists of individuals and household's expenditure on consumable goods and services such as health services, cloths, sports, entertainment (television sets, movies, music), local tourism, transport, food and beverages, education services, water, electricity, vehicles, internet and telephone services [19]. Consumption depends on real disposable income (i.e. after tax), wealth, price level, expectations, habits and life styles, demographic factors, health status, etc. Premature mortality due to NCDs (or any other cause) decreases disposable income and wealth, which in turn reduces total consumption and demand for commodities. Simply put dead people do not consume goods and services!

Investment refers to purchase of capital goods used in production, e.g. land, farm equipment, residential and business buildings, machinery, construction equipment, etc. Individuals and households usually save the disposable income that is not consumed. In turn those savings are used for investment. The decision to invest greatly depends on interest rates, tax incentives, expectations, business confidence and regulations [19]. Premature mortality reduces number of people who save income (since the dead do not earn income they also do not save); and compels households to spend their savings on funeral services and ceremonies. In addition, the growing incidence, prevalence and mortality from NCDs in the African Region may negatively impact on investor expectations, and thus, could also reduce the levels of investment in countries.

Central, provincial/regional and local government total expenditure entails purchase of goods and services, for example, remuneration for civil servants, security forces equipment and services, office buildings and equipment (e.g. computers, printers), office supplies, infrastructure (sanitation systems, irrigation schemes, railway, roads, airport terminals) [19]. The funds spent by government come from tax revenues and borrowing to finance budget deficits. Tax revenues are a function of total income from individuals, households and business enterprises. Premature mortality from NCDs reduces the total taxable income, and hence, total tax revenues. Put simply, the dead people do not pay taxes!

Net export is the difference between total value of goods and services exported (sold) by an African country to other countries and the funds spent by national individuals, households and business enterprises on the purchase of goods and services produced in other countries (imports) [19]. Import expenditure is a function of disposable income, price of imported goods relative to the price of locally produced goods, national currency exchange rate into foreign currency (e.g. US dollars), import taxes, import quotas, trade sanctions, etc. Exports are determined by similar factors. Premature mortality due to NCDs reduces the numbers of producers of exports. Again dead people neither export nor import goods and services.

The population health status in recipient African country is likely to influence foreign capital inflows of funds for the purpose of investment into fixed and financial assets. The other determinants of capital inflows into a country depend on relative interest rates on financial investments, relative rates of return on real asset investment, exchange rate, economic and political expectations [19]. The growing incidence and prevalence of disease (e.g. NCDs) and related mortality may erode confidence among the foreign direct investors. The negative impact of disease on foreign investment was vividly demonstrated in the recent Ebola Disease outbreak in Wes Africa [20].

According to WHO (21,p.4) "..it is important to note that GDP includes expenditure on health goods and services, so this component should be omitted and the focus of analysis be redirected towards establishing the present value of discounted aggregate flows of current and future consumption of non-health related goods and services linked to disease (p.4)." The current study aims to assess the economic consequences of NCD deaths on the aggregate impact on society, i.e. macroeconomic level. In terms of scope, it assesses only losses associated with the market economy of African region countries. The focus is on overall productivity losses. Since that is our focus, WHO [21] and Chisholm et al [22] advises that that the quantity of interest ought to be the impact on the combined output of paid and unpaid workers as measured by non-health GDP.

The non-health GDP loss (NHGDPLoss) associated with NCDs deaths in a country is the sum of the potential non-health GDP loss due to NCD deaths among those aged 0-4 ($NHGDPLoss_{0-4}$), those aged 5-14 ($NHGDPLoss_{5-14}$), those aged 15-29 ($NHGDPLoss_{15-29}$), those aged 30-59 ($NHGDPLoss_{30-29}$), those aged 60-69 ($NHGDPLoss_{60-69}$) and those aged 70 years and above ($NHGDPLoss_{=>70}$). The productivity losses among the six age brackets were estimated to avail information on the age groups most economically impacted by NCDs and for comparative purposes.

The non-health GDP loss associated with NCD deaths among persons of a specific age group is the product of the total discounted years of life lost, per capita non-health GDP in purchasing power parity (PPP) and the total NCD deaths (TND) [23]. Each country's discounted total non-health GDP loss attributable to NCD deaths was estimated using the equations (1) to (6) below [24].

$$NHGDPLoss = \begin{pmatrix} NHGDPLoss_{0-4} + NHGDPLoss_{5-14} + NHGDPLoss_{15-29} + \\ NHGDPLoss_{30-59} + NHGDPLoss_{60-69} + NHGDPLoss_{\geq 70} \end{pmatrix} \quad (1)$$

$$NHGDPLoss_{0-4} = \sum_{t=1}^{n} \left\{ 1/(1+r)^t \times [NHGDPPC_{Int\$}] \times [TND_{0-4}] \right\} =$$
$$\left\{ 1/(1+r)^1 \times [NHGDPPC_{Int\$}] \times [TND_{0-4}] \right\} +$$
$$\left\{ 1/(1+r)^2 \times [NHGDPPC_{Int\$}] \times [TND_{0-4}] \right\} + ... +$$
$$\left\{ 1/(1+r)^n \times [NHGDPPC_{Int\$}] \times [TND_{0-4}] \right\} \quad (2)$$

$$NHGDPLoss_{5-14} = \sum_{t=1}^{n} \left\{ 1/(1+r)^t \times [NHGDPPC_{Int\$}] \times [TND_{5-14}] \right\} =$$
$$\left\{ 1/(1+r)^1 \times [NHGDPPC_{Int\$}] \times [TND_{5-14}] \right\} +$$
$$\left\{ 1/(1+r)^2 \times [NHGDPPC_{Int\$}] \times [TND_{5-14}] \right\} + ... +$$
$$\left\{ 1/(1+r)^n \times [NHGDPPC_{Int\$}] \times [TND_{5-14}] \right\} \quad (3)$$

$$NHGDPLoss_{15-29} = \sum_{t=1}^{n} \left\{ 1/(1+r)^t \times [NHGDPPC_{Int\$}] \times [TND_{15-29}] \right\} =$$
$$\left\{ 1/(1+r)^1 \times [NHGDPPC_{Int\$}] \times [TND_{15-29}] \right\} +$$
$$\left\{ 1/(1+r)^2 \times [NHGDPPC_{Int\$}] \times [TND_{15-29}] \right\} + ... +$$
$$\left\{ 1/(1+r)^n \times [NHGDPPC_{Int\$}] \times [TND_{15-29}] \right\} \quad (4)$$

$$NHGDPLoss_{30-59} = \sum_{t=1}^{n} \left\{ 1/(1+r)^t \times [NHGDPPC_{Int\$}] \times [TND_{30-59}] \right\} =$$
$$\left\{ 1/(1+r)^1 \times [NHGDPPC_{Int\$}] \times [TND_{30-59}] \right\} +$$
$$\left\{ 1/(1+r)^2 \times [NHGDPPC_{Int\$}] \times [TND_{30-59}] \right\} + ... +$$
$$\left\{ 1/(1+r)^n \times [NHGDPPC_{Int\$}] \times [TND_{30-59}] \right\} \quad (5)$$

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$$NHGDPLoss_{60-69} = \sum_{t=1}^{n}\left\{\left[1/(1+r)^{t}\right] \times \left[NHGDPPC_{Int\$}\right] \times \left[TND_{60-69}\right]\right\} =$$

$$\left\{\left[1/(1+r)^{1}\right] \times \left[NHGDPPC_{Int\$}\right] \times \left[TND_{60-69}\right]\right\} +$$

$$\left\{\left[1/(1+r)^{2}\right] \times \left[NHGDPPC_{Int\$}\right] \times \left[TND_{60-69}\right]\right\} + ... +$$

$$\left\{\left[1/(1+r)^{n}\right] \times \left[NHGDPPC_{Int\$}\right] \times \left[TND_{60-69}\right]\right\} \qquad 6$$

$$NHGDPLoss_{\geq70} = \sum_{t=1}^{n}\left\{\left[1/(1+r)^{t}\right] \times \left[NHGDPPC_{Int\$}\right] \times \left[TND_{\geq70}\right]\right\} =$$

$$\left\{\left[1/(1+r)^{1}\right] \times \left[NHGDPPC_{Int\$}\right] \times \left[TND_{\geq70}\right]\right\} +$$

$$\left\{\left[1/(1+r)^{2}\right] \times \left[NHGDPPC_{Int\$}\right] \times \left[TND_{\geq70}\right]\right\} + ... +$$

$$\left\{\left[1/(1+r)^{n}\right] \times \left[NHGDPPC_{Int\$}\right] \times \left[TND_{\geq70}\right]\right\} \qquad 7$$

Where: $1/(1+r)^{t}$ is the discount factor that converts future GDP losses into today's dollars; r is an interest rate that measures the opportunity cost of lost earnings; $\sum_{t=1}^{n}$ is the summation from year t to n; t is the first year of life lost, and n is the final year of the total number of years of life lost per NCD death, which is obtained by subtracting the average age at death (AAD) for NCD-related causes from each country's average life expectancy at birth; $NHGDPPC_{Int\$}$ is per capita non-health GDP in purchasing power parity (PPP), which is obtained by subtracting per capita total health expenditure ($PCTHE$) from per capita GDP ($GDPPC_{Int\$}$); TND_{0-4} is the total NCD deaths between the age of 0-4 years in country k in 2012; TND_{5-14} is the total NCD deaths between the age of 5-14 years in country k in 2012; TND_{15-29} is the total NCD deaths between the age of 15-29 years in country k in 2012; TND_{30-59} is the total NCD deaths between the age of 30-59 years in country k in 2012; TND_{60-69} is the total NCD deaths between the age of 60-69 years in country k in 2012; and $TND_{\geq70}$ is the total NCD deaths between the age of 70 years and above in country in 2012. We used 2013 as the base year to which GDP losses occurring in future years were discounted. As explained by Kirigia et al [25], Kirigia [26], Drummond *et al* [27] and Curry and Weiss [28] the discount factor applied to the

GDP losses of different years depends on both the discount rate (r) and the number of years (t) over which the discounting is conducted.

The non-health GDP per capita in purchasing power parity for each of the 45 countries is the difference between per capita GDP and per capita total health expenditure [25].

Illustration of calculation of loss in total non-health GDP

The example below on calculation of non-health GDP losses associated with NCD deaths uses actual information on Democratic Republic of Congo (DRC):

(a) Total NCD deaths in DRC in 2012 = 215,744

(b) Proportion of deaths among those aged 0-4 years = 0.108113103

(c) Proportion of deaths among those aged 5-14 years = 0.087301048

(d) Proportion of deaths among those aged 15-29 years = 0.072475597

(e) Proportion of deaths among those aged 30-59 years = 0.264066276

(f) Proportion of deaths among those aged 60-69 years = 0.17244842

(g) Proportion of deaths among those aged 70+ years = 0.295595556

(h) TND_{0-4} = 215744 x 0.108113103 = 23,325

(i) TND_{5-14} = 215744 x 0.087301048 = 18,835

(j) TND_{15-29} = 215744 x 0.072475597 = 15,636

(k) TND_{30-59} = 215744 x 0.264066276 = 56,971

(l) TND_{60-69} = 215744 x 0.17244842 = 37,205

(m) TND_{70} = 215744 x 0.295595556 = 63,773

(n) Average age at death among those aged 0-4 years (AAD_{0-4}), i.e. (0+4)/2 = 2 years

(o) Number of years needed, in addition to AAD_{0-4} to reach the legal minimum age for employment of 15 years (Age_{0-4Min}), i.e. 12 years.

(p) Average age at death among those aged 5-14 years (AAD_{5-14}), i.e. (5+14)/2 = 9.5 years

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(q) Number of years needed, in addition to AAD_{5-14} to reach the legal minimum age for employment of 15 years ($Age_{5-14Min}$), i.e. 4.5 years.

(r) Average age at death among those aged 15-29 years (AAD_{15-29}), i.e. (15+29)/2 = 22 years

(s) Average age at death among those aged 30-59 years (AAD_{30-59}), i.e. (30+59)/2 = 44.5 years

(t) Average age at death among those aged 60-69 years (AAD_{60-69}), i.e. (60+69)/2 = 64.5 years

(u) Average age at death among those aged 70 years and above ($AAD_{\geq 70}$), i.e. 70 years

(v) DRC's average life expectancy at birth (LE) = 52 years

(w) Per capita gross domestic product ($GDPPC_{Int\$}$) = Int\$ 381.662

(x) Per capita total expenditure on health ($PCTHE$) = Int\$ 25

(y) $NHGDPPC = GDPPC_{Int\$} - PCTHE =$ 381.662 - Int\$ 25 = Int\$ 357.05

(z) Discount rate (r) = 3%

(aa) Undiscounted years of life lost in the group aged 0-4 years (YLL_{0-4}) = LE − ($AAD_{0-4} + Age_{0-4Min}$) = 52 − (2 + 12) = 38 years

(bb) Discounted years of life lost in the group aged 0-4 years ($DYLL_{0-4}$) = 22.49246159

(cc) Undiscounted years of life lost in the group aged 5-14 years (YLL_{5-14}) = LE − ($AAD_{5-14} + Age_{5-14Min}$)= 52 − (9.5 + 4.5) = 38 years

(dd) Discounted years of life lost in the group aged 5-14 years ($DYLL_{5-14}$) = 22.49246159

(ee) Undiscounted years of life lost in the group aged 15-29 years (YLL_{15-29}) = LE - AAD_{15-29} = 52 − 22 = 30 years

(ff) Discounted years of life lost in the group aged 15-29 years ($DYLL_{15-29}$) = 19.60044135

(gg) Undiscounted years of life lost in the group aged 30-59 years (YLL_{30-59}) = LE - = 52 − 44.5= 8 years

(hh) Discounted years of life lost in the group aged 30-59 years ($DYLL_{30-59}$) = 7.01969219

(ii) Undiscounted years of life lost in the group aged 60-69 years (YLL_{60-69}) = LE - AAD_{60-69} = 0 (since the DRC average LE of 52 years is less than 60 years, we assumed that years of life lost within this age group are zero. However, this assumption is adjusted in the sensitivity analysis where we re-estimate the model using highest life expectancy in the region, i.e. 75 years in Cape Verde).

(jj) Discounted years of life lost in the group aged 60-69 years ($DYLL_{60-69}$) equals zero for reason explained in 'ii' above.

(kk) Undiscounted years of life lost in the group aged 70+ years ($YLL_{70\pm}$) = LE - $AAD_{70\pm}$ = 0 (since the DRC average LE of 52 years is less than 70 years, we assumed that years of life lost within this age group are zero. However, this assumption is adjusted in the sensitivity analysis where we re-estimate the model using highest life expectancy in the region, i.e. 75 years in Cape Verde).

(ll) Discounted years of life lost in the group aged 70+ years ($DYLL_{70+}$) equals zero for reason explained in 'kk' above.

(mm) $NHGDPLoss_{0-4} = DYLL_{0-4}$ x $NHGDPPC_{Int\$}$ x TND_{0-4} = 22.49246159 x 357.05 x 23325 = Int\$ 187,321,522

(nn) $NHGDPLoss_{5-14} = DYLL_{5-14}$ x $NHGDPPC_{Int\$}$ x TND_{5-14} = 22.49246159 x 357.05 x 18835 = Int\$ 151,262,631

(oo) $NHGDPLoss_{15-29} = DYLL_{15-29}$ x $NHGDPPC_{Int\$}$ x TND_{15-29} = 19.60044135 x 357.05 x 15636 = Int\$ 109,426,006

(pp) $NHGDPLoss_{30-59} = DYLL_{30-59}$ x $NHGDPPC_{Int\$}$ x TND_{30-59} = 7.01969219 x 357.05 x 56971 = Int\$ 142,791,037

(qq) $NHGDPLoss_{60-69} = DYLL_{60-69}$ x $NHGDPPC_{Int\$}$ x TND_{60-69} = 0 x 357.05 x 37205 = Int\$ 0.

(rr) $NHGDPLoss_{70} = DYLL_{70}$ x $NHGDPPC_{Int\$}$ x TND_{70} = 0 x 357.05 x 63773 = Int\$ 0.

(ss) $NHGDPLoss =$

$$\begin{pmatrix} NHGDPLoss_{0-4} + NHGDPLoss_{5-14} + NHGDPLoss_{15-29} + \\ NHGDPLoss_{30-59} + NHGDPLoss_{60-69} + NHGDPLoss_{\geq 70} \end{pmatrix} =$$

Int$ 187,321,522 + Int$ 151,262,631 + Int$ 109,426,006 + Int$ 142,791,037 + Int$ 0 + Int$ 0 = Int$ 590,801,196.

Due to manual rounding up of decimal points in this example the value of total non-health GDP loss for DRC is Int$ 2,028 less than the estimate reported in the Results section.

Sensitivity analysis

We employed a discount rate of 3% which is commonly used in cost-of-illness studies [23, 29, 30], burden of disease studies [31, 32] and WHO health systems' performance assessment [33, 34]. In order to assess the effect of the discount rate on the total non-health GDP loss, a one-way sensitivity analysis was done at 5% and 10% discount rates.

The study used a simple average of 2 years as age at death for the 0-4 age bracket; 9.5 years for the 5-14 age bracket; 22 years for the 15-29 bracket; 44.5 years for 30-59 age bracket; 64.5 years for the 60-69 age bracket; and 70 years for the 70 years and above age bracket. Given that according to International Labour Organization the legal minimum working age limit is 15 years [35], only the years above 14 years were considered when calculating the productive years of life lost for the 0-4 and 5-14 years' age brackets. A sensitivity analysis was conducted to determine the effect of age on

the total non-health GDP loss estimate. The model was re-estimated assuming Region's maximum life expectancy of 75 years (i.e. life expectancy for Cape Verde) for all countries instead of their actual life expectancies.

Data sources and analysis

The data used to estimate the seven equations were obtained from following sources: the life expectancy at birth data and per capita total health expenditure data were from WHO World Health Statistics 2015 [1]; the numbers and proportions of NCD deaths occurring in the six age groups were from the WHO mortality and burden of disease estimates for 2012 [36, 37, 38]; and the per capita gross domestic product in purchasing-power-parity (PPP) value was from the International Monetary Fund database [39].

The formulas in equations (1) to (7) used to estimate non-health GDP losses were built in an Excel spreadsheet. For the analysis, the countries were put into three economic groups as shown in **Table 3**, with high and upper middle income countries in Group 1, lower middle income countries in Group 2 and low income countries in Group 3. The grouping was for comparative purposes.

Ethical clearance

The study did not require ethical clearance since it did not involve human subjects. It was based completely on statistical data from published public sources.

Table 3. Economic classification of WHO African Region Countries in 2013.

	Group	GNI per capita (US$)	Countries
1	High income and upper middle income	>=4086	Algeria, Angola, Botswana, Equatorial Guinea, Gabon, Mauritius, Namibia, Seychelles, South Africa (9)
2	Lower middle income	1036 – 4085	Cameroon, Cape Verde, Congo, Cote d'Ivoire, Ghana, Kenya, Lesotho, Mauritânia, Nigeria, São Tome and Príncipe, Senegal, Swaziland, Zambia (13)
3	Low income	1035 or less	Benin, Burkina Faso, Burundi, Central African Republic, Chad, Comoros, DRC, Eritrea, Ethiopia, The Gambia, Guinea, Guinea-Bissau, Liberia, Madagascar, Malawi, Mali, Mozambique, Niger, Rwanda, Sierra Leone, South Sudan, Tanzania, Togo, Uganda, Zimbabwe (25)

Results

Table 4 presents the WHO African Region's population and NCD deaths by economic group in 2012. Of the total of 2,788,381 NCD deaths that occurred, 19.13% were borne by the high and upper middle-income countries (Group 1), 33.86% by the lower middle-income countries (Group 2) and 47.1% by the low-income countries (Group 1).

Table 4. Population and NCD deaths by economic group in WHO African Region countries.

Group/ Economic Class	(A) Population in 2013	(B) NCD Deaths in 2012	Percentage = (B/A)*100%
High income & upper middle income	121,453,000	533,335	0.439
Lower middle income	331,470,000	944,212	0.285
Low income	478,356,000	1,310,834	0.274
Total	931,279,000	2,788,381	0.299

Source: WHO [1, 12]

Non-health GDP loss attributable to NCD deaths

The 2,788,381 NCD deaths that occurred in the African Region in 2012 would be expected to have reduced future non-health GDP by Int$ 61,302,450 005 **(Table 5)**. Approximately 20.36% of the loss occurred among the 0-4 year olds, 12.76% among the 5-14 year olds, 16.64% among the 15-29 year olds, 44.93% among the 30-59 year olds, 2.99% among the 60-69 year olds and 2.33% among the 70 years and above. Thus, those aged between 15 and 59 years bore 61.57% of the GDP losses.

Almost 47.4% of the total loss was borne by Group 1 countries, 33.1% by group 2 and 19.5% by group 3. The loss of future discounted non-health GDP varied widely from Int$ 22,527,447 in Comoros to Int$ 11,775,478,271 in Nigeria. Eight countries had a GDP loss of less than Int$ 100,000,000. Sixteen countries had a GDP loss of between Int$ 100,000,000 and Int$ 500,000,000. Nine countries had a GDP loss of between Int$ 500,000,001 and Int$ 999,999,999. Twelve countries had a GDP loss of Int$ 1,000,000,000 and above. **(Table 5)**

Table 5. Discounted values of future non-health GDP losses from NCD deaths among WHO African Region countries in 2012 (2013, Int$ or PPP).

Countries	International Dollars (PPP)	Percentage
Algeria	10,058,897,065	16.41
Angola	4,186,150,549	6.83
Benin	408,108,873	0.67
Botswana	533,317,211	0.87
Burkina Faso	675,259,822	1.10
Burundi	171,688,237	0.28
Cameroon	1,506,654,501	2.46
Cape Verde	67,022,695	0.11
Central African Republic	48,031,457	0.08
Chad	690,932,911	1.13
Comoros	22,527,447	0.04
Congo	484,262,668	0.79
Cote D'Ivoire	1,008,632,995	1.65
DRC	590,803,224	0.96
Equatorial Guinea	544,689,838	0.89
Eritrea	91,460,462	0.15
Ethiopia	2,385,084,092	3.89
Gabon	595,622,251	0.97
Gambia	95,743,953	0.16
Ghana	2,537,879,410	4.14
Guinea	323,830,276	0.53
Guinea Bissau	47,942,803	0.08
Kenya	1,561,634,123	2.55
Lesotho	55,038,720	0.09
Liberia	57,286,023	0.09
Madagascar	472,046,266	0.77
Malawi	216,531,490	0.35
Mali	474,825,935	0.77
Mauritania	162,177,437	0.26
Mauritius	1,143,857,025	1.87
Mozambique	609,267,013	0.99
Namibia	317,143,359	0.52
Niger	307,457,475	0.50
Nigeria	11,775,478,271	19.21

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Countries	International Dollars (PPP)	Percentage
Rwanda	375,892,473	0.61
Senegal	583,001,206	0.95
Sierra Leone	214,672,603	0.35
South Africa	11,705,397,936	19.09
South Sudan	527,094,663	0.86
Swaziland	113,181,726	0.18
Tanzania	1,635,458,126	2.67
Togo	190,314,011	0.31
Uganda	1,171,154,967	1.91
Zambia	437,753,426	0.71
Zimbabwe	121,242,990	0.20
Total GDP LOSS (Int$)	61,302,450,005	100.00

Group 1 countries' non-health GDP loss

The 533,335 NCD deaths in Group 1 countries resulted in a total loss of Int$ 29,085,075,234 in non-health GDP in 2013, which equivalent to 2.59% of the group's total GDP. The total loss varied from Int$ 317,143,359 in Namibia to Int$ 11,705,397,936 in South Africa. **Figure 1** shows the distribution of Group 1's total non-health GDP loss across the eight High income and upper middle-income countries (data for Seychelles was missing). About 74.8% of the Group 1's loss was borne by Algeria and South Africa.

Figure 1: Group1. Non-health GDP loss due to NCD deaths in high income & upper middle-income countries of WHO African Region in 2013.
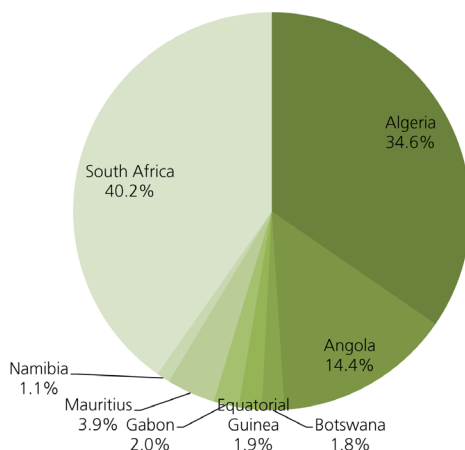
Group 2 countries' non-health GDP loss

The 944,212 NCD deaths in Group 2 countries resulted in a total loss of Int$ 20,292,717,178 in non-health GDP, or 2.4% of the group's total GDP. The loss varied widely from Int$ 55,038,720 in Lesotho to Int$ 11,775,478,271 in Nigeria. **Figure 2** depicts the distribution of Group 2's total non-health GDP loss across the 12 lower middle-income countries (data for Cape Verde was missing). Almost 70.5% of the Group 2's loss was borne by Ghana and Nigeria.

Figure 2: Group 2. Non-health GDP loss due to NCD deaths in lower middle income countries of WHO African Region in 2013.
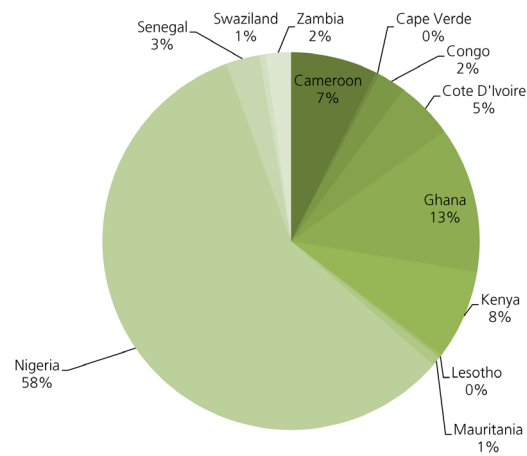
Group 3 countries' non-health GDP loss

The 1,310,834 NCD deaths that occurred among Group 3 countries in 2012 resulted in a total loss in non-health GDP of Int$ 11,924,657,593, which is equivalent to 2.59% of the group's total GDP. The loss varied from Int$ 22,527,447 in Comoros to Int$ 2,385,084,092 in Ethiopia. **Figure 3** shows the distribution of Group 3's total non-health GDP loss across the 25 low-income countries. Chad, Ethiopia, Mozambique, Tanzania and Uganda collectively incurred 54.4% of the loss in this group. Inspite of the fact that Group 3 NCD deaths were 2.5 times those of Group 1, the non-health GDP loss of Group 1 was 2.4 times higher than that of Group 3 because Group 1 had higher GDP per capita.

Figure 3: Group 3. Non-health GDP loss due to NCD deaths in low income countries of WHO African Region in 2013.
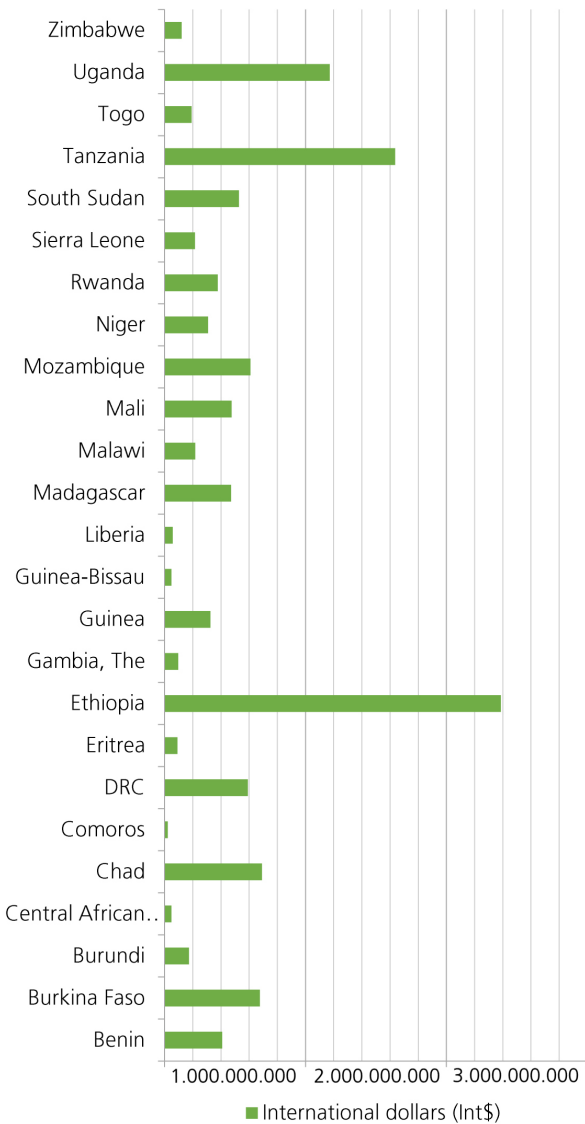
countries in the African Region. The average non-health GDP lost per NCD death was Int$ 54,534 for Group 1, Int$ 21,492 for Group 2 and Int$ 9,097 for Group 3. The average non-health GDP loss per person in the population was Int$ 239.5 for Group 1, Int$ 61.2 for group 2 and Int$ 24.9 for Group 3. The average non-health GDP loss per death for Group 1 was 2.5 times that for Group 2 and six times that for Group 3.

Sensitivity Analysis

The use of a 5% discount rate resulted in a reduction in total non-health GDP loss of Int$ 12.23 billion (19.9%) and the average non-health cost per NCD death by Int$ 4,384.61. Application of a 10% discount rate reduced the overall total non-health GDP loss by Int$ 29,068,744,059 (47.4%) and the average non-health GDP loss per NCD death by Int$ 10,425.

The use of average ages at death of 2 years for age bracket 0-4 years; 9.5 years for the age bracket 5-14 years; 22 years for the 15-29 age bracket; 44.5 years for the 30-59 age bracket; 64.5 years for the 60-69 age bracket; and 70 years for the 70 years and above age bracket, while simultaneously assuming Region's maximum life expectancy of 75 years raised the total non-health GDP loss by Int$ 51,433 billion, which is a 83.9% increase; and the average non-health GDP loss per NCD death increased by In$ 18,445.

Average non-health GDP losses

Table 6 presents the average non-health GDP losses per NCD death and per person in population for 45

Discussion

The estimated total expected non-health GDP loss attributed to NCD deaths of Int$ 61.3 billion is about

Table 6. Discounted values of future non-health GDP lost due to NCD deaths in 2012 by economic group (at 2013 international dollars).

Cost item	Group 1 (Int$)	Group 2 (Int$)	Group 3 (Int$)	Grand total Cost (Int$)
Total cost of NCD deaths	29,085,075,234	20,292,717,178	11,924,657,593	61,302,450,005
Average cost per NCD death	54,534	21,492	9,097	21,985
Average cost per person in population	239.5	61.2	24.9	65.8
% of Grand Total	47.4	33.1	19.5	100.0

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2.4% of the collective GDP of the 45 WHO African Region Member States. That estimate depicts the potential future GDP loss from the 2,788,381 NCD deaths revalued relative to the base year 2013. Sensitivity analysis revealed that the size of total non-health GDP loss partially depends on the discount rate used and the average ages used for the onset of NCD deaths. Thus, there is need for epidemiological research into the age distribution of NCD deaths.

The Group 3 (low income) countries that are the home of 51.4% of the African Region population, incurred 47% of NCD deaths, and bore only 19.5% of non-health GDP losses associated with NCD deaths in the Region. On the other hand, even though Group 1 (High income and upper middle income) countries have only 13.1% of the Regional population and incurred only 19.13% of NCD deaths, it bore 47.4% of the non-health GDP losses associated with NCD in the Region. This is attributed to the fact that the Group 1 per capita income of Int$ 9,257 is eight times higher than that of Group 3 countries of Int$ 1,131.

A number of factors might explain why Groups 1 (lower middle income) and 2 (upper middle incomes) incurred lower percentage of NCD deaths than those of Group 3. First, the difference could be attributed to lower health risks in Groups 1 and 2. For instance, 27.7% of adult (aged 18 years and above) males and 28.2% of females in low-income countries had raised blood pressure compared to 26.2% and 24.7% in lower middle-income countries and 22.3% and 18.7% in upper middle-income countries [1]. Second, the density of health infrastructure and health technologies among low-income countries (Group 3) is lower than that of lower (Group 2) and upper (Group 1) middle-income countries. For example, there were 0.1 radiology units per million population in low income countries compared to 0.4 radiology units per million population in lower middle income countries and 1.2 radiology units per million population in upper middle inco-

me countries. Density of physicians in low-income countries was 2.5 per 10,000 population compared to 7.9 in lower middle-income countries and 16.1 per 10,000 population in upper middle-income countries in 2013. The density of nursing and midwifery personnel in low-income countries was 5.3 per 10,000 contrasted with 18 per 10,000 in lower middle-income countries and 26.3 per 10,000 in upper middle-income countries [1]. Thirdly, per capita total expenditure on health in low-income countries was Int$ 83 compared with Int$ 235 in lower middle-income countries and Int$ 766 in upper middle-income countries. Fourth, literacy rate among adults aged 15 years and above was 63%, 71% and 94% in low-income, lower middle-income and upper middle-income countries. Fifth, population living below poverty line was 43.6%, 22.7% and 5.2% in low-income, lower middle-income and upper middle-income countries. Sixth, gross national income per capita was Int$ 1,780, Int$ 5,953 and Int$ 13,402 in low-income, lower middle-income and upper middle-income countries.

Concerned that the growing global burden of NCDs undermines socioeconomic development throughout the world and threatens the achievement of internationally agreed development goals, the UN General Assembly (UNGA) in 2011 adopted the Political Declaration of the High-level Meeting of the General Assembly on the Prevention and Control of Non-Communicable Diseases [40]. On 25 September 2015 the UNGA adopted the 2030 development agenda consisting of 17 Sustainable Development Goals and 169 targets [41]. The SDG 3 is to ensure healthy lives and promote wellbeing for all at all ages. Three of the 13 SDG3 targets are related to NCDs. Target 3.4 is on reducing by one-third (by 2030) premature mortality from NCD through prevention and treatment and promotion of mental health and wellbeing. Target 3.5 is on strengthening the prevention and treatment of substance abuse, including narcotic drug abuse and harmful use of alcohol. Target 3.9 aims to substantially reduce the

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number of deaths and illnesses from hazardous chemicals and air, water and soil pollution and contamination. Target 3 (a) is geared at strengthening the implementation of the WHO Framework Convention on Tobacco Control in all countries; and target 3(b) is on supporting the research and development of vaccines and medicines for the communicable and non-communicable diseases.

The Sixty-Sixth World Health Assembly through resolution WHA A66.10 [42, 43] endorsed the WHO global action plan for prevention and control of NCDs and adopted a comprehensive global monitoring framework [44]. The resolution urges Member States to implement the action plan; enhance the capacity, mechanisms and mandates of relevant authorities in facilitating and ensuring action across government sectors; strengthen collaborative partnerships with non-health and non-State actors at national, subnational and/or local levels for the prevention and control of NCDs; develop national NCD monitoring frameworks; accelerate implementation past WHO resolution related to Global Strategy for the Prevention and Control of NCDs [45, 46], mental health [47], health and the environment [48], FCTC [49], diet, physical activity and health [50], harmful use of alcohol [51], marketing of foods and non-alcoholic beverages to children [52], healthy aging [53]; establish/strengthen national surveillance and monitoring system; and provide adequate, predictable and sustained resources for national programmes for prevention and control of NCDs.

At the Continental level, the African Union Ministers of Health in 2014 committed to ensuring that the WHO global action plan for the prevention and control of NCDs (2013-2020) is fully implemented through the National NCD multi-sectorial plans and resources from both innovative domestic and external financing [54]. Before then, in 2008, the AU Executive Council through Decision EX.CL.Dec.436 (XIII) endorsed the adoption of the last Friday of February each Year to be the Africa Healthy Lifestyles Day [55]. The decision was adopted within the

framework of the WHO Strategy for prevention and control of NCDs [45], which underscores that adopting a healthy lifestyle involves regular physical exercise, healthy eating habits, reducing stress, avoiding tobacco use and alcohol abuse.

At the African Region level, the WHO Regional Committee over the years has adopted resolutions on healthy aging [56]; Brazzaville Declaration on NCDs [57]; harmful use of alcohol [58]; social determinants of health [59]; diabetes prevention and control [60]; food safety and health [61]; cardiovascular [62]; health and environment [63]; health promotion [64,65]; non-communicable diseases regional strategy [66]. As acknowledged by the AU-WHO Ministers of Health [67] and reflected in the increasing trends of burden of NCDs [68], the abovementioned UNGA, WHA, AU and RC declarations, decisions, commitments and resolutions have not been fully implemented in the Africa largely due to inadequate allocation of domestic resources to combat NCDs [69].

According to WHO [68] a large percentage of NCDs are preventable through the reduction of their four main behavioural risk factors: tobacco use, physical inactivity, harmful use of alcohol and unhealthy diet. WHO considers the population-wide and individual health-care interventions in **Table 7** to be cost-effective.

One may ask whether those interventions in **Table 7** are economically viable. WHO [68, 70] estimated the average yearly cost of scaling up coverage of a combination of population-based and individual-based interventions for all low- and middle-income countries to be US$ 11.4 billion (an overall cost of US$ 170 billion over the period 2011-2025). That cost translated into annual cost per person in population of approximately US$ 1 in low-income countries, US$ 1.50 in lower-middle income countries and US$ 2.50 in upper-middle income countries.

As shown in **Table 8**, if we inflate those 2011 average costs by 3% per year over a period of 2 years (to 2013) [70], multiply them by respective economic

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Table 7. Cost-effective population-wide and individual health-care interventions.

Risk factors and associated core intervention set: Best buys	
Population-based interventions addressing NCD risk factors	Tobacco use: Tax increases; smoke-free indoor workplaces and public places; health information and warnings about tobacco; bans on advertising and promotion
	Harmful alcohol use: Tax increases on alcoholic beverages; comprehensive restrictions and bans on alcohol marketing; restrictions on the availability of retailed alcohol
	Unhealthy diet and physical inactivity: Salt reduction through mass media campaigns and reduced salt content in processed foods; replacement of trans-fats with polyunsaturated fats; public awareness programme about diet and physical activity
Individual-based Interventions addressing NCDs in primary care	Cancer: Prevention of liver cancer through hepatitis B immunization; prevention of cervical cancer through screening (visual inspection with acetic acid) and treatment of pre-cancerous lesions
	CVD and diabetes: Multi-drug therapy (including glycaemic control for diabetes mellitus) to individuals who have had a heart attack or stroke, and to persons with a high risk (> 30%) of a CVD event in the next 10 years; providing aspirin to people having an acute heart attack
Source: WHO [68].	

Table 8. Total cost of NCD interventions and benefit-cost ratio for Africa.

Variables	Population*	Cost per person ($)**	Sub-Total Cost ($)
Low-income countries	121,453,000	1.061	322,123,719.25
Lower-middle income countries	331,470,000	1.591	527,484,784.50
Upper-middle income countries	478,356,000	2.652	507,487,880.40
Undiscounted total cost (USD)			1,357,096,384.15
(A). Discounted total cost (Int$) at a 3% rate			1,279,193,500
(B). GDP Loss (potential saving)			61,302,450,005
Source: : *WHO [1]; **WHO [70].			

group population [1] and sum them up we obtain a total undiscounted cost of US$ 1,357,096,384, which when discounted at 3% comes to $1,279 193,500. Dividing the GDP loss (which is potential saving) of $61.3 billion by cost of NCD interventions of $1.28 billion yields a benefit-cost ratio (BCR) of 47.9 meaning that policymakers can expect $47.9 in benefits for every $1 invested in the NCD interventions in **Table 7**. Therefore, since the BCR is greater than 1 this means the benefits outweigh the costs and the investment into the NCD interventions contained in **Table 7** should be considered worthwhile.

The substantive productivity losses caused by premature NCD-related mortality underscores the urgent need African governments to form a compact with their domestic and external development partners to fully implement the WHO global action plan for the prevention and control of NCDs with a view to preventing premature deaths from NCDs.

Limitations of the study

The study has a number of limitations. First, the estimated losses do not represent total cost-of-illness associated with NCDs since costs of diagnosis, treatment, and care (direct costs) prior to death were omitted. Direct costs include cost of health systems inputs, public health campaigns, research and household non-medical costs such as the cost of transport to a health services provider.

Second, the productivity losses associated with reduced labour force participation and efficiency due to non-fatal chronic illnesses; and lost time of family and friends accompanying the sick to health facilities and visiting those hospitalized were not in-

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cluded. Third, the cost of physical and psychological pain and suffering from chronic illness was omitted.

Fourth, the actual population epidemiological burden (deaths and non-fatal disability) of many NCDs is not known [71]. This is because the integrated disease surveillance strategies and systems in Africa do often not include major NCDs and risk factors [72]. Therefore, even the NCD mortality figures used in the current study have been produced through modelling studies that used existing scanty data of common risk factors [73].

Fifth, the use of foregone contributions to GDP to measure the value of health and life rests on the assumptions that changes in health status are reflected in changes in earnings and national income; and GDP is a valid measure of social welfare [74, 75]. While the first assumption might be plausible, some scholars have argued that GDP is not a valid measure of change in societal wellbeing [76, 77]. Card and Mooney also criticized the human capital approach for not taking account either the existing decision-making processes in the health service (or views of individual patients at risk); and for implying that the sole objective of health care is to add to productive capacity of a nation [78].

Conclusion

The study reported in this paper contributes to the extant literature on the economic losses associated with NCDs. The 45 WHO African Region Member States lost 2.45% of their combined GDP due to the 2,788,381 NCD deaths in 2012. The eight high income and upper middle-income countries of the Region bore almost half of the total non-health GDP loss of Int$ 61.3 billion. Approximately 61.6% of the loss was borne by those aged 15-59 years, which is the most productive age bracket.

The negative effect of NCD premature deaths on GDP means that African countries governments in collaboration with the domestic, regional and international development partners ought to accelerate implementation of the Global action plan for the prevention and control of NCDs [43, 79] with a view to achieving the related SDG 3 targets [41].

Since the results reported in this paper represents only the productivity losses associated with NCDs, there is need for further research into direct costs of diagnosis, treatment, and care. That is essential so that the national health and economic development policy-makers and non-state actors can have a complete picture of the magnitude of total economic loss associated with NCDs. Such information would further reinforce the case for increased investments to stem the growing tide of NCDs burden in the African Region.

Abbreviations

AAD: Average age at death;

AAD_{0-4}: Average age at death for those aged 0–4 years;

AAD_{5-14}: Average age at death for those aged 5-14 years;

AAD_{15-29}: Average age at death for those aged 15-29 years;

AAD_{30-59}: Average age at death for those aged 30-59 years;

AAD_{60-69}: Average age at death for those aged 60-69 years;

$AAD_{=>70}$: Average age at death for those aged 60 years and above;

DYLL: Discounted years of life lost;

$DYLL_{0-4}$: Discounted years of life lost in the group aged 0-4 years;

$DYLL_{5-14}$: Discounted years of life lost in the group aged 5-14 years;

$DYLL_{15-29}$: Discounted years of life lost in the group aged 15-29 years;

$DYLL_{30-59}$: Discounted years of life lost in the group aged 30-59 years;

$DYLL_{60-69}$: Discounted years of life lost in the group aged 60-69 years;

$DYLL_{\geq70}$: Discounted years of life lost in the group aged 70 years and above;

GDP: Gross domestic product;

$GDP_{Int\$}$: Per capita GDP in International Dollars;

Int$: International dollars;

LE: Life expectancy at birth;

n: Final year of the total number of years of life lost per death associated with NCD;

NCD: Noncommunicable disease

$NHGDPPPC_{Int\$}$: Per capita non-health GDP in PPP;

NHGDPLoss: Non-health GDP loss;

$NHGDPLoss_{0-4}$: Non-health GDP loss in the 0-4 years age group;

$NHGDPLoss_{5-14}$: Non-health GDP loss in the 5-14 years age group;

$NHGDPLoss_{15-29}$: Non-health GDP loss in the 15-29 years age group;

$NHGDPLoss_{30-29}$: Non-health GDP loss in the 30-59 years age group;

$NHGDPLoss_{60-69}$: Non-health GDP loss in the 60-69 years age group;

$NHGDPLoss_{\geq70}$: Non-health GDP loss in the 70 years age group;

PCTHE: Per capita total health expenditure;

PPP: Purchasing power parity;

PYLL: Productive years of life lost;

r: Rate of discount of future losses;

SDG: Sustainable Development Goals

t: First year of life lost;

TDR: United Nations Special Programme for Research and Training in Tropical Diseases;

TND: Total number of deaths associated with NCD;

TND_{0-4}: Total NCD deaths associated with NCD in the 0-4 years age group;

TND_{5-14}: Total NCD deaths associated with NCD in the 5-14 years age group;

TND_{15-29}: Total NCD deaths associated with NCD in the 15-29 years age group;

TND_{30-59}: Total NCD deaths associated with NCD in the 30-59 years age group;

TND_{60-69}: Total NCD deaths associated with NCD in the 60-69 years age group;

$TND_{\geq70}$: Total NCD deaths associated with NCD in the 70 years and above age group;

UNGA: United Nations General Assembly;

WHO: World Health Organization;

YLL_{0-4}: Undiscounted years of life lost in the group aged 0-4 years;

YLL_{5-14}: Undiscounted years of life lost in the group aged 5-14 years;

YLL_{15-29}: Undiscounted years of life lost in the group aged 15-29 years;

YLL_{30-59}: Undiscounted years of life lost in the group aged 30-59 years;

YLL_{60-69}: Undiscounted years of life lost in the group aged 60-69 years;

$YLL_{\geq70}$: Undiscounted years of life lost in the group aged 70 years and above.

Authors' contributions

JMK, GMM and JMM contributed to the study design, analysis of the data and the writing of the manuscript. LHKN, RDKM and EB participated in data analysis, conducted literature review, and contributed in writing the background and discussion sections. All authors read and approved the final paper.

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Competing interests

The authors declare that they have no competing interests.

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