JOGHEP

Senkubuge F, Hongoro C, Muthuri Kirigia J. Dollar value of disability-adjusted life years in South Africa in 2019. *Journal of Global Health Economics and Policy*. 2021;1:e2021004. doi:10.52872/001c.26856

Original articles

Dollar value of disability-adjusted life years in South Africa in 2019

Flavia Senkubuge[1], Charles Hongoro[2], Joses Muthuri Kirigia[3]

[1] School of Health Systems and Public Health, University of Pretoria, South Africa, [2] Department of Developmental, Capable and Ethical State, Human Sciences Research Council (HSRC), Pretoria, South Africa, [3] African Sustainable Development Research Consortium (ASDRC), Nairobi, Kenya

Keywords: human capital approach, dollar value, disability-adjusted life-years, south africa, economics

https://doi.org/10.52872/001c.26856

Journal of Global Health Economics and Policy

Vol. 1, 2021

Background

To date, no study has estimated the dollar value of DALYs lost from a wide range of diseases and conditions in South Africa. The specific objectives of this study were: (a) to estimate the dollar value of disability-adjusted life-years (DALYs) lost in South Africa in 2019, and (b) to forecast the reductions in the dollar value of DALY losses assuming the United Nations Sustainable Development Goal 3 (SDG3) five disease-specific targets are attained by 2030.

Methods

The study employs the human capital approach to convert the DALYs lost from all causes into their International Dollar (Int$) equivalents. The DALYs data used in the analysis was from the Institute for Health Metrics and Evaluation (IHME) Database, per capita GDP data from the International Monetary Fund (IMF) Database, and current health expenditure per person from the Global Health Expenditure Database of the World Health Organization (WHO).

Results

South Africa lost 26.6 million DALYs in 2019 with a total value of Int$ 313.5 billion and an average value of Int$ 11,791.6 per DALY. Approximately Int$ 155.6 billion (50%) was attributed to communicable, maternal, neonatal, and nutritional diseases (CMNND); Int$ 120.4 billion (38%) to non-communicable diseases (NCD); and Int$ 37.4 billion (12%) to injuries (INJ). The health conditions related to SDG3 targets 3.1 (maternal mortality), 3.2 (neonatal mortality), 3.3 (CMNND), 3.4 (NCD) and 3.6 (INJ) resulted in DALY losses with a value of 256.4 billion, i.e. 82% of the total monetary value of DALYs lost in 2019. Therefore, achieving the five SDG targets would potentially save South Africa Int$ 139.7 billion per year.

Conclusions

Health development policy-makers should employ this type of evidence when making a case for increased investments into the national health-related systems to bridge the extant gap in the universal health service coverage index for South Africa.

BACKGROUND

South Africa's population was 58.78 million people in 2019. It is an upper-middle-income country with a gross domestic product (GDP) of International Dollars (Int$) 761.82 billion,[1] per capita GDP of Int$ 12,961.7[1] and inequality-adjusted human development index of 0.468 in 2019.[2]

In the same year, the country had a total of 26,587,883 disability-adjusted life-years (DALYs) from all causes.[3] Out of which, 50% were from communicable, maternal, neonatal, and nutritional diseases (CMNND); 38% from non-communicable diseases (NCD); and 12% from injuries (INJ).[3]

The persistent, significant loss in DALYs has been attributed to the sub-optimal performance of three sets of systems. First, the national,[4–6] district,[7,8] and community health system responsible for assuring affordable access to quality health services.[9,10] Rispel *et al.* uncovered human resources for health gaps and weaknesses that ought to be addressed to ensure a high performing health system.[10] According to the WHO World Statistics 2020, the universal health coverage (UHC) service coverage index for South Africa was 69% in 2017, which implied a 31% service coverage gap.[11] The index encompasses reproductive, maternal, newborn and child health, infectious diseases, and non-communicable diseases service capacities and access. About 384,300 (1.4%) of South Africans had household expenditures on health greater than 10% of total household expenditure or incomes, and 27,450 (0.1%) had household expenditures on health greater than 25% of total household expenditure or incomes in 2017.[11]

Second, the systems addressing social determinants of health, including food, education, water, sanitation, shelter (dwelling) and physical security.[12] About 27% of children under the age of five were stunted, 2.5% were wasted, and 13.3% were overweight in 2017.[11] Approximately 5.6% of adults aged 15 years and older are illiterate, and 24% have no secondary school education.[12] Seven per cent of the population were not using improved drinking water sources, and 34% were not using improved sanitation.[13] Around 79% of households live in a formal dwelling, 14% in informal dwelling, 6% in traditional dwelling and 1% in other dwellings.[14] The community reported 1,662,815 serious crimes between 1st April 2017 to 31st March 2018. About 29% of crimes occurred in Gauteng, 21% in Western Cape, 15% in Kwazulu-Natal, 10% in Eastern Cape, 6% in Mpumalanga, 6% in North-West, 6% in Limpopo, 5% in Free State and 2% in Northern Cape.[15]

Finally, the national health research system is meant to produce high-quality contextualized knowledge and promote its use in developing resilient and sustainable systems to promote population health.[16] Senkubuge et al. estimated the overall NHRS barometer score of South Africa to be 84%, implying a performance deficit of 16%.[17] The authors recommended actions needed to bridge deficits in NHRS financing and human plus physical resources.[17]

The sub-optimal performance of the national health system may partially be associated with the fact that current health expenditures (CHE) per capita for South Africa of $471 is less than the US$536 per person recommended for the attainment of United Nations (UN) Sustainable Development Goal 3 (SDG3).[18,19] Stenberg et al. also recommended that about 60% of CHE per person consist of general government expenditure on health. There is a need for advocacy for increased government investment in the health system and other systems that address social determinants of health[12]; improved equity in health and health-related spending[20,21]; and efficient use of health development resources.[22–24]

Monetary valuations of health losses have been estimated and used in Africa,[25–28] Asia,[29–32] Eastern Mediterranean,[33–35] European,[36–41] North American,[42–45] and South American countries to advocate for increased investments into health development.[46–49] To date, no study has estimated the dollar value of DALYs lost from a wide range of diseases and conditions in South Africa. Thus, this study aims to contribute to bridging the existing knowledge gap.

The specific objectives were: (a) to estimate the dollar value of DALYs lost in South Africa in 2019; and (b) to forecast the reductions in the dollar value of DALY losses assuming some specific SDG 3 targets are attained by 2030.

METHODS

STUDY AREA AND DISEASE CATEGORIES

The study reported in this paper centres on the International Dollar (or Purchasing Power Parity) valuation of the 26.6 million DALYs from 157 causes in South Africa in 2019.[3] Its scope included three disease clusters. First, the CMNND cluster comprised 24 infectious and parasitic diseases, three respiratory infections, maternal disorders, neonatal disorders, and five nutritional deficiencies. Second, the NCD cluster consisted of 30 neoplasms, three diabetes and kidney diseases, ten mental disorders, two substance use disorders, seven neurological disorders, three sense organ disorders, 11 cardiovascular diseases, five chronic respiratory diseases, ten digestive diseases, three sense organ diseases, 12 skin and subcutaneous diseases, six musculoskeletal diseases, seven other NCDs (congenital disabilities; urinary diseases and male infertility; gynaecological diseases; haemoglobinopathies and haemolytic anaemias; endocrine, metabolic, blood, and immune disorders; oral disorders; sudden infant death syndrome).[3] Third, the injuries cluster consisted of 17 causes, including two transport injuries, 11 unintentional injuries, and four self-harm and interpersonal violence.[3]

The DALY is a sum of years of life lost (YLL) due to premature mortality in the population and the years of life lost to disability (YLD) for people living with a health condition.[50] The YLD is obtained by multiplying disability weights by the number of years lived in a specific health state. The Institute for Health Metrics and Evaluation (IHME) GBD 2019 Diseases and Injuries Collaborators article describes methods and data sources used in 2019 DALY estimations.[51]

ESTIMATION OF THE DOLLAR VALUE OF DALY LOST IN SOUTH AFRICA IN 2019

The Organization for Economic Cooperation and Development (OECD) defines human capital (HC) as "The health (longevity and quality of life), knowledge, skills, competencies and attributes embodied in individuals that facilitate the creation of personal, social and economic wellbeing (p.18)".[52] There is a substantial body of evidence of a negative correlation between ill-health and risky health behaviours and educational achievement and academic performance.[53,54] Poor health negatively affects educational outcomes by causing learning disabilities,[55,56] eroding concentration,[57–59] and reducing school attendance.[60] Past research has revealed that good health has a statistically significant positive effect on the gross domestic product (GDP) or aggregate output.[61,62]

The study reported in this paper employed the HC approach (HCA) presented below to estimate the dollar value of DALYs from various causes. We chose to use HCA because of the availability of data on South Africa's DALY per cause, current health expenditure per person, and GDP per person.

$$TDVD = (DVD_{CMNN} + DVD_{NCD} + DVD_{INJ}) \quad (1)$$

As done in similar studies,[63,64] DVD from each CMNN, NCD and INJ were estimated by multiplying the DALYs associated with different causes by South Africa's 2019 GDP per capita (GDPPC) net of current health expenditure per person (CHEP). The DVD from jth cause (disease or injury) was estimated using the following formula:

$$DVD_j = DALY_j \times (GDPPC_{INT\$} - CHEP_{INT\$}) \quad (2)$$

where: $DALY_j$ is the number of DALYs lost from jth disease or injury; $GDPPC_{INT\$}$ is the GDP per person ($GDPPC_{INT\$}$) in International Dollars (Int$) or Purchasing Power Parity; $CHEP_{INT\$}$ is the current health expenditure per person in International Dollars. A discount factor was not introduced in equation (2) since DALY estimates from the IHME global

Table 1. Health UN SDG3 targets and envisioned percentage reductions for South Africa

(A). Target	*(B). Description*	*(C). Percentage reduction envisaged in SDG targets*
SDG 3.1	By 2030, reduce the global maternal mortality ratio (MMR) to less than 70 per 100,000 live births.[65] That is from South Africa's MMR of 119 per 100,000 in 2017.[11]	41.18%
SDG 3.2	3.2 By 2030, end preventable deaths of newborns and children under 5 years of age, with all countries aiming to reduce neonatal mortality to at least as low as 12 per 1,000 live births and under-5 mortality to at least as low as 25 per 1,000 live births.[65]	-
	SDG3.2(a) Reduce neonatal mortality rate (NMR) to South Africa's target of 7 per 1,000 live births by 2030.[66] That is from South Africa's NMR of 11.45 per 1,000 live births in 2018.[11]	38.86%
	SDG3.2(b) Reduce under-5 mortality (U5MR) to at least as low as 25 per 1,000 live births by 2030.[65] That is from South Africa's U5MR of 34.46 per 1,000 live births in 2018.[11]	27.45%
SDG 3.3	By 2030, end the epidemics of AIDS, tuberculosis, malaria and neglected tropical diseases and reduce hepatitis, water-borne diseases and other communicable diseases.[65]	-
	(a). Reduce South Africa HIV-related deaths from 126,805 in 2019 to 21,436 in 2030.[66,67]	83.10%
	(b). Malaria mortality rates will be reduced in South Africa by at least 90% from 79 per 100,000 population in 2019 to 7.9 per 100,000 in 2030.[65,68,69]	90%
	(c). The number of tuberculosis (TB) deaths in South Africa will be reduced from 22,000 in 2019 to 3,404 in 2030.[66,70,71]	84.53%
	(d). Mortality due to vector-borne diseases in South Africa from 80.55 in 2019 to 20.1375 in 2030.[3,65,72]	75%
	(e). Reduce viral hepatitis B and C deaths in South Africa from 124 in 2019 to less than 43 by 2030.[3,73,74]	65%
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 From 228,966 NCD-related deaths in 2019 to 152,645 NCD deaths in South Africa in 2030.[3,65]	33.33%
SDG 3.6	By 2020, halve the number of global deaths from road traffic accidents.[65] From 19,239 road injuries deaths in 2019 to 9,620 deaths in 2030.[3,65]	50%

Sources: Global Burden of Disease Collaborative Network,[3] World Health Organisation (WHO),[11] United Nations (UN),[65] Republic of South Africa,[66] World Health Organization (WHO).[67–74]

burden of disease database are already discounted at a rate of 3%.[3]

It is illustrated below how the dollar value of DALYs from road injuries (DVD_{RINJ}) in 2019 was estimated using Equation 2. The DALYs from road injuries ($DALY_{RINJ}$) were 1,051,493; $GDPPC_{INT\$}$ was Int$12,961.702; and $CHEP_{INT\$}$ was Int$ 1,170.098852 in 2019. Hence:

$$\begin{aligned} DVD_{RINJ} =& DALY_{RINJ} \\ & \times (GDPPC_{INT\$} - CHEP_{INT\$}) \\ =& 1,051,493 \\ & \times \lfloor 12961.702 - 1170.098852 \rfloor \\ =& Int\$12,398,792,099 \end{aligned} \quad (3)$$

FORECAST OF THE DOLLAR VALUE OF DALYS LOST IN SOUTH AFRICA IN 2030

The dollar value of forecast DALY losses in 2030 (MVD_{j2030}) assumes achievement of the SDG3 targets in Table 1. Those targets include maternal mortality ratio (Target 3.1), neonatal mortality (Target 3.2), HIV/AIDS deaths (Target 3.3), tuberculosis (Target 3.3), malaria (Target 3.3), neglected tropical diseases (NTD) (Target 3.3), hepatitis (Target 3.3), NCD (Target 3.4), and injuries (Target 3.6).

The percentage reductions from baseline year (Y_1) to the SDG deadline year of 2030 (Y_2), which are contained in Column C of Table 1, were calculated using the following formula: $((Y_2\text{-}Y_1)/|Y_1|) \times 100$. For instance, for road traffic injuries-related deaths (SDG3.6), percentage change from Y_1=19,239 in 2019 to Y_2=9,620 deaths in 2030 = ((9620 – 19239)/|19239|) x 100 = -50% change or 50 % decrease.

The anticipated dollar value of DALYs expected to accrue to South Africa in 2030 was estimated using the following equation[28]:

$$\begin{aligned} MVD_{j2030} =& MVD_{j2019} \\ & - \left[MVD_{j2019} \times (SDG_{jER} \,/\, 100) \right] \end{aligned} \quad (4)$$

Where: MVD_{j2030} is the total dollar value of DALY loss expected from j[th] health condition in 2030 assuming attainment of the related target; MVD_{j2019} is the total dollar value of DALYs lost from j[th] health condition in the year 2019; and SDG_{jER} is the SDG j[th] health condition expected percentage reduction in mortality by 2030 contained in Table 1.[28]

As an example, it is demonstrated below how the dollar value of DALYs from RINJ in 2030 ($MVD_{RINJ2030}$) was appraised. The $MVD_{RINJ2019}$ for South Africa in 2019 was Int$ 12,398,792,099, and SDG target 3.6 is to reduce the number of deaths from road injuries by 50% ($(SDG_{RINJ}$). Thus:

$$\begin{aligned} MVD_{RINJ2030} =& MVD_{RINJ2019} \\ & - \left[MVD_{RINJ2019} \right. \\ & \left. \times (SDG_{RINJ} \,/\, 100)\right] \\ =& 12,398,792,099 \\ & - \left[12,398,792,099 \times \left(\frac{50}{100}\right)\right] \\ =& Int\$\ 6,199,396,050 \end{aligned} \quad (5)$$

ESTIMATION OF DOLLAR VALUE OF DALYS LOSSES PREVENTED BY 2030

Following Kirigia and Mwabu[28] and Muthuri and Kirigia,[75] the dollar value of expected DALY losses likely to be prevented by ultimately achieving SDG3 target j (j = 3.1, 3.2, 3.3, 3.4, 3.6) contained in Table 1 (MVD_{SDG3j_Saving}) was calculated using the following formula:

$$MVD_{SDG3j\_Saving} = [MVD_{j2019} - MVD_{j2030}] \quad (6)$$

For instance, the potential dollar value of DALYs saved by attaining SDG3 target 3.6 on road injuries ($MVD_{SDG3.6\_Saving}$) was appraised as follows:

$$\begin{aligned} MVD_{SDG3.6_{Saving}} &= [MVD_{RINJ2019} - MVD_{j2030}] \\ &= (12,398,792,099 \\ &\quad - 6,199,396,050) \\ &= Int\$6,199,396,050 \end{aligned} \quad (7)$$

DATA SOURCES AND ANALYSIS

The 2019 DALYs data estimates for the 157 causes for South Africa was from the Global Burden of Disease Collaborative Network database,[3] and data on GDP per person in 2019 (Int$12,961.702) was from the International Monetary Fund (IMF) World Economic Outlook database.[1] The projection of current health expenditure per capita (Int$1,170.098852) in 2019 used data from the WHO Global Health Expenditure Database.[18] Since the CHEPC were Int$1,129.38391113 and Int$1,090.08569336 in 2018 and 2017,[18] rate of change equals 0.0360505765825344 (3.60506%). Therefore, the CHEPC for 2019 equals Int$1,170.098852, i.e. Int$1129.38391113 + (Int$1129.38391113 x 0.0360505765825344). The net GDP per capita equals Int$11,791.6031476907, i.e. 12,961.702 minus 1,170.098852.

Equation (2) was estimated for each of the 157 causes (disease or injury) of DALY losses. In addition, equations (4) and (5) were calculated for SDG targets 3.1, 3.2, 3.3, 3.4 and 3.6. The seven equations developed in this methods section were analysed using Excel Software of Microsoft (New York).

RESULTS

ESTIMATES OF DOLLAR VALUE OF DALYS IN SOUTH AFRICA IN 2019

All causes: In 2019, South Africa incurred a total loss of 26.6 million DALYs from all causes valued at Int$313.5 billion. That is an average value of Int$ 11,791.6 per DALY. Out of the total value of DALYs, 50% accrued to CMNND, 38% to NCD, and 12% to INJ.

Figure 1 portrays the dollar value of DALYs from all causes by age groups. The South Africans aged 14 years and less sustained DALYs worth Int$ 53.5 billion (17%); the 15-59 year-olds incurred DALYs worth Int$ 199.7 billion (64%); 60-year-olds and above bore DALYs worth Int$ 60.3 billion (19%). Therefore, US$ 216.5 billion (69%) of the total dollar value of DALYs lost occurred among people aged between 15 years and 64 years, i.e. the most economically productive age bracket.

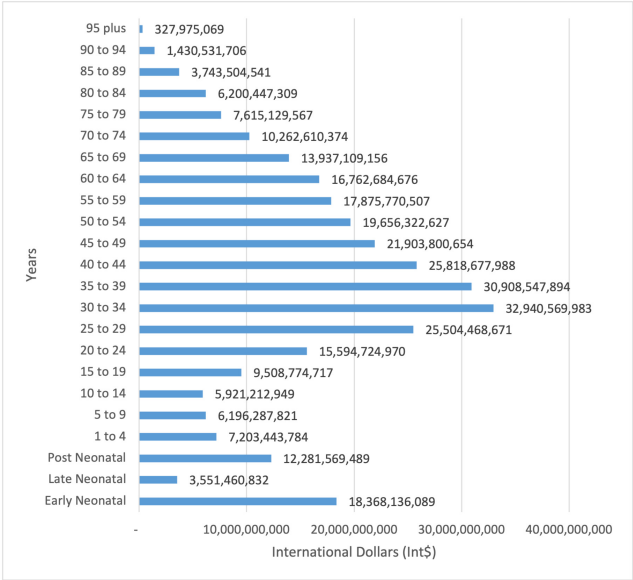

Figure 1. The dollar value of disability-adjusted life years (DALYs) from all causes by age groups in South Africa (2019 Int$)

Note: The early neonatal refers to age 0 to 6 days, late neonatal 7 to 27 days, and postnatal 28 to 364 days.[51]

COMMUNICABLE, MATERNAL, NEONATAL, AND NUTRITIONAL DISEASES

Figure 2 shows the dollar value of DALYs various CMNND categories. Of the total dollar value of DALYs from CMNND of Int$ 155.6 billion, 60% emanated from HIV/AIDS and sexually transmitted infections; 15% from respiratory infections and tuberculosis; 14% from maternal and neonatal disorders; 5% from enteric infections; 3% from other infectious diseases; 2% from nutritional deficiencies; and 1% from Neglected Tropical Diseases (NTD) and Malaria. Thus, about 91% of the total dollar value of DALYs was from five causes, i.e. HIV/AIDS, neonatal disorders, lower respiratory infections, tuberculosis, and diarrheal diseases.

NONCOMMUNICABLE DISEASES

Figure 3 illustrates the dollar value of DALYs from the main categories of NCDs. Out of the total DALYs from NCDs valued at Int$ 120.4 billion, 18% was ascribed to cardiovascular diseases; 14% to neoplasms; 12% to diabetes and kidney diseases; 9.1% to mental disorders; 7.3% to musculoskeletal disorders; 6.1% to chronic respiratory diseases; 6.0% to neurological disorders; 5.0% to digestive diseases; 5.0% to sense organ diseases; 3% to substance use disorders; 2.5% to skin and subcutaneous diseases; and 12% to other non-communicable diseases (congenital birth defects, urinary diseases and male infertility, gynaecological diseases,

haemoglobinopathies and haemolytic anaemias, oral disorders, and sudden infant death syndrome). On the other hand, diabetes mellitus, stroke, ischemic heart disease, depressive disorders, and chronic kidney disease made up 29% of the dollar value of DALYs from NCDs.

INJURIES

Figure 4 presents the dollar value of DALYs from all seventeen forms of injuries. Injuries caused DALYs worth a total of Int$ 37.4 billion. Self-harm and interpersonal violence accounted for Int$ 17.5 billion (47%), transport injuries for Int$ 12.8 billion (34%), and unintentional injuries for Int$ 7.1 billion (19%). Eighty-seven per cent of the total dollar value of DALYs from injuries was due to interpersonal violence (34%), road injuries (33%), self-harm (13%), drowning (3%), and fire, heat, and hot substances (4%).

DOLLAR VALUE OF DALYS IN 2019 FROM FIVE SDG3-RELATED TARGETS

In 2019 SDG3-related diseases and health conditions resulted in a total of 21.7 million DALYs that had a dollar value of Int$ 256.4 billion (82%). As depicted in Table 2, 90% of the dollar value of SDG-related DALYs accrued to neonatal mortality, HIV/AIDS, and NCDs alone.

FORECAST OF REDUCTIONS IN DOLLAR VALUE OF DALY LOSSES IN SOUTH AFRICA ASSUMING THE FIVE SDG 3-RELATED TARGETS ARE ACCOMPLISHED BY 2030

Table 3 portrays the dollar value of DALYs in 2019, the dollar value of DALYs in 2030, and predicted savings per SDG health condition/disease.

We forecast that attaining the five SDG3 targets would lead to approximately a 45% (Int$139.75 billion) drop in the total national dollar value of DALYs by 2030.

DISCUSSION

KEY FINDINGS

According to Institute for Health Metrics and Evaluation (IHME) Global Burden of Disease Collaborative Network database, the Republic of South Africa incurred a total of 26.6 million DALYs from all causes in 2019.[3] Using net GDP per capita of Int$ 11,791.60 per DALY, the study reported in this paper valued the national stock of DALYs at Int$313.5 billion.

It would be wrong to assume that if all the causes of DALY loss were eradicated, South Africa would increase the total GDP of Int$313.5 billion. That is because 28.7% of South Africa's total labour force was unemployed in 2019, and people aged below 15 years and above the compulsory retirement age of 64 are arguably not part of the labour force.[1] When ratifying the International Labour Organization (ILO) Minimum Age Convention of 1973, South Africa specified the minimum employment age as 15 years.[76]

Critiques may argue that the DALYs lost among the population aged below 15 years and above the compulsory retirement age should be valued at zero. However, the total dollar value of DALYs lost among people aged between 15 and 64 years was Int$216.5 billion in 2019. Adjusting this estimate further by unemployment rate yields a value of Int$ 154 billion, i.e. 216.5 x ((100 - 28.7)/100)). That is equivalent to 20% of South Africa's total GDP of US$ 761.8 billion in 2019. Therefore, it is clear that even with adjustment for both minimum working age and unemployment rate, disease burden exerts a significant burden on South Africa's economy.

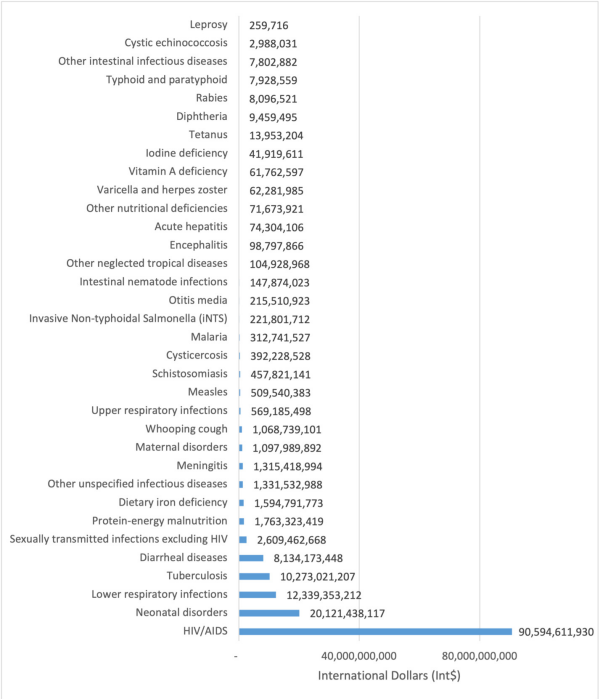

Figure 2. The dollar value of disability-adjusted life years (DALYs) from communicable, maternal, neonatal, and nutritional diseases in South Africa (2019 Int$)

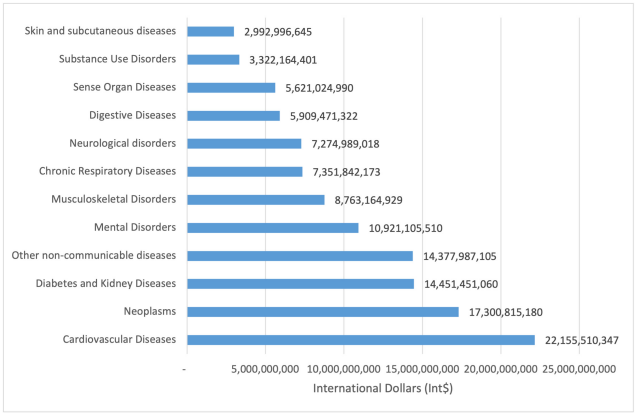

Figure 3. The dollar value of disability-adjusted life years (DALYs) from noncommunicable diseases in South Africa (2019 Int$)

Table 2. Dollar value of DALYs in 2019 from five SDG3-related targets (2019 Int$)

SDG3 targets	DALYs in 2019	Dollar Value of DALYs (Int$)	Percent
SDG 3.1: Maternal mortality	93,116	1,097,989,892	0.43
SDG 3.2: Neonatal mortality	1,706,421	20,121,438,117	7.85
SDG 3.3: Tuberculosis	871,215	10,273,021,207	4.01
SDG 3.3: HIV/AIDS	7,682,977	90,594,611,930	35.33
SDG 3.3: Malaria	26,522	312,741,527	0.12
SDG 3.3: Acute hepatitis	6,301	74,304,106	0.03
SDG 3.3: NTDs	94,491	1,114,196,929	0.43
SDG 3.4: NCDs	10,214,262	120,442,522,683	47
SDG 3.6: Road injury	1,051,493	12,398,792,099	4.8
Total for SDG-related	**21,746,799**	**256,429,618,490**	**100**

IMPLICATIONS FOR POLICY

SDG3.1 AND SDG3.2: MATERNAL AND NEONATAL DISORDERS

South Africa could prevent loss of DALYs worth approximately Int$ 8.3 billion per year if SDG targets SDG3.1 and SDG3.2 are accomplished by 2030. In 2017 South Africa had a universal health coverage index for reproductive, maternal, newborn and child (RMNCH) health services of 79 (where the target is 100),[77] signifying a gap of 21 points, which need bridging to have a chance of realising targets SDG3.1 and SDG3.2. According to the Department of Health, attainment of SDG3.1 and SDG3.2 will require universal coverage of maternal health services, vaccines against preventable diseases, and integrated management of childhood diseases services detailed in the national health sector strategic plan.[66] Development of the RMNCH aspects of South Africa's strategic plan 2020/21-2024/25 was informed by the WHO Regional Committee for Africa (RC) road map for accelerating the attainment of the MDGs related to maternal and newborn health in Africa[78]; the global strategy for women's, children's and adolescents' health (2016-2030) (GSWCAH),[79] and its operational framework.[80] The development of South Africa's strategic plan was also apprised by the WHO World Health Assembly (WHA) resolutions on GSWCAH[81]; maternal, infant and young child nutrition[82,83]; female genital mutilation[84]; global vaccine plan[85,86]; the role of the health system within a national multisector response to address interpersonal violence against women, girls and children[87]; global newborn health action plan[88]; global immunisation strategy[89]; United Nations Commission on Life-Saving Commodities for Women and Children recommendations[90]; and reduction of perinatal and neonatal mortality.[91]

Implementation of the interventions contained in the strategic plan for reducing maternal, child, infant, and neonatal mortalities is underpinned by section 27 of the South Africa Constitution that assures right of access to health care, food, water and social security[92]; the National Health Act of 2003[93]; the Choice on Termination of Pregnancy Act of 1996[94]; the National Health Insurance Bill.[95]

The South African Government efforts to curb maternal, child, infant, and neonatal mortality are buttressed by pertinent African Union declaration,[96] and Charters on human and people's rights on women's rights in Africa,[97] and the rights and welfare of the child.[98]

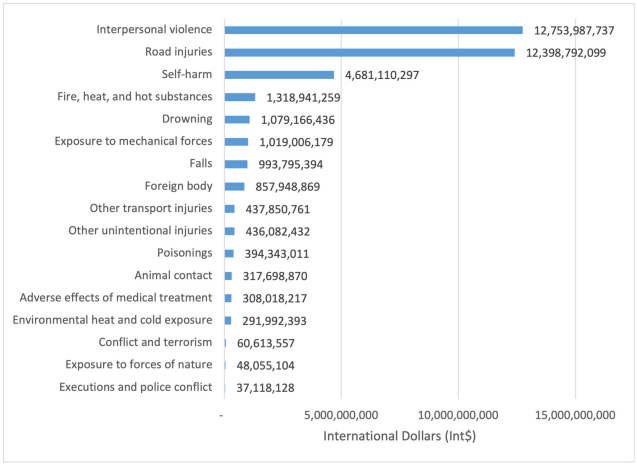

Figure 4. The dollar value of disability-adjusted life years (DALYs) from injuries in South Africa (2019 Int$)

Furthermore, the Government's actions to curb maternal, child and neonatal mortality are in line with recent United General Assembly Resolutions on the elimination of all forms of violence against women and girls[99]; elimination of female genital mutilation[100]; intensification of efforts to end obstetric fistula[101]; high-level political declarations on UHC[102]; rights of the child[103]; and preventable maternal mortality and morbidity and human rights.[104]

SDG3.3 TUBERCULOSIS, HIV/AIDS, MALARIA, ACUTE HEPATITIS, AND NTDS

The attainment of SDG target 3.3 would annually save South Africa DALYs worth approximately Int$ 75.3 billion from HIV/AIDS, Int $8.7 billion from tuberculosis, Int$ 835.6 million from NTDs, Int$ 281.5 million from malaria, and Int$ 48.3 million from acute hepatitis. In short, the country would salvage DALYs with a total value of Int$ 85.13

Table 3. Dollar value of DALYs by SDG3 health conditions (2019 Int$)

Health conditions/diseases	*(A). Dollar Value of DALYs in 2019 (Int$)*	*(B). Predicted dollar Value of DALYs in 2030 (Int$)*	*(C). Reduction in Dollar Value of DALYs in 2030 (Int$) [C=A-B)*
SDG 3.1: Maternal mortality	**1,097,989,892**	**645,876,407**	**452,113,485**
SDG 3.2: Neonatal mortality	**20,121,438,117**	**12,301,315,879**	**7,820,122,238**
SDG 3.3: Tuberculosis deaths	**10,273,021,207**	**1,589,516,554**	**8,683,504,653**
SDG 3.3: HIV/AIDS deaths	**90,594,611,930**	**15,314,743,909**	**75,279,868,022**
SDG 3.3: Malaria deaths	**312,741,527**	**31,274,153**	**281,467,375**
SDG 3.3: Acute hepatitis	**74,304,106**	**26,006,437**	**48,297,669**
SDG 3.3: NTDs (a+b+..+g)	**1,114,196,929**	**278,549,232**	**835,647,697**
(a). Schistosomiasis	457,821,141	114,455,285	343,365,855
(b). Cysticercosis	392,228,528	98,057,132	294,171,396
(c). Cystic echinococcosis	2,988,031	747,008	2,241,023
(d). Rabies	8,096,521	2,024,130	6,072,391
(e). Intestinal nematode infections	147,874,023	36,968,506	110,905,517
(f). Leprosy	259,716	64,929	194,787
(g). Other neglected tropical diseases	104,928,968	26,232,242	78,696,726
SDG 3.4: Non-communicable diseases (a+b+c+..+l)	**120,442,522,683**	**80,295,416,597**	**40,147,106,086**
(a). Cardiovascular Diseases	22,155,510,347	14,770,414,083	7,385,096,264
(b). Neoplasms	17,300,815,180	11,533,934,456	5,766,880,724
(c).Diabetes and Kidney Diseases	14,451,451,060	9,634,348,878	4,817,102,182
(d). Mental Disorders	10,921,105,510	7,280,773,411	3,640,332,100
(e).Musculoskeletal Disorders	8,763,164,929	5,842,139,163	2,921,025,766
(f). Chronic Respiratory Diseases	7,351,842,173	4,901,252,622	2,450,589,552
(g). Neurological disorders	7,274,989,018	4,850,016,929	2,424,972,090
(h). Digestive Diseases	5,909,471,322	3,939,667,246	1,969,804,076
(i). Sense Organ Diseases	5,621,024,990	3,747,368,730	1,873,656,260
(j). Substance Use Disorders	3,322,164,401	2,214,787,341	1,107,377,060
(k). Skin and subcutaneous diseases	2,992,996,645	1,995,341,073	997,655,572
(l). Other non-communicable diseases	14,377,987,105	9,585,372,663	4,792,614,442
SDG 3.6: Road injury	**12,398,792,099**	**6,199,396,050**	**6,199,396,050**
SDG TOTAL (INT$)	**256,429,618,490**	**116,682,095,218**	**139,747,523,273**

billion.

The UHCSCI component of these infectious diseases had a score of 62, denoting a shortfall of 38 in coverage of health services/interventions aimed at preventing and controlling HIV/AIDS, TB, NTDs, malaria, and acute hepatitis.[77] Bridging the gap calls for full implementation of the infectious diseases strategies and actions outlined in the Department of Health Strategic Plan 2020/21-2024/25.[66]

The development of goals, targets, strategies, and actions aimed at combating infectious diseases was informed by the WHO World Health Assembly (WHA) resolutions on preventing and controlling HIV and viral hepatitis,[105] TB,[106] malaria,[107] and vector-borne diseases.[108,109]

Pertinent African Union decisions/documents[110–115] and the United Nations General Assembly Resolutions[116–119] underpin South Africa's efforts to implement strategies and actions to attain infectious diseases-related SDG3 target 3.3.

SDG3.4: NCDS

South Africa would salvage DALYs worth Int$40.15 billion should it succeed in attenuating the disease burden from NCDs by a third by 2030 (SDG target 3.4).[65] The UHCSCI

component of NCDs had a score of 58 (on a scale of 0-100),[77] signifying a deficit of 42 points in coverage of health services/interventions targeted at addressing associated risk factors. Such a gap in coverage of essential health services ought to be bridged by implementing NCD strategies and actions in the Department of Health Strategic Plan 2020/21-2024/25.[66] The development of goals, targets, strategies and actions geared at bridging NCD services gaps were informed by the WHO World Health Assembly (WHA) resolutions titled global action plan on physical activity 2018–2030[120]; global strategy on diet, physical activity and health[121]; global action plan for the prevention and control of NCD 2013–2020[122]; the global strategy for the prevention and control of NCD[123]; the comprehensive mental health action plan 2013–2020[124]; the WHO Framework Convention on Tobacco Control.[125] The implementation of the NCD-related strategies and actions in the South Africa Department of Health Strategic Plan 2020/21-2024/25 is reinforced by the African Union Commitment AUC-WHO/COM.3/2014 on NCDs in Africa,[126] and the United Nations General Assembly Resolutions A/RES/74/2,[127] A/RES/66/2,[128] and A/RES/74/244[129] on prevention and control of NCDs, and resolution A/RES/74/244 on consuming fruits and vegetables.[130]

SDG 3.6: ROAD INJURIES

South Africa to half the road injuries by 2030 (SDG target 3.6)[65] would save DALYs worth Int$6.2 billion. The achievement of SDG target 3.6 depends on both performance of Road Traffic Management Corporation (TRMC), mandated by law to manage road traffic and enforce relevant laws, and the national health system provision of adequate coverage of pre-hospital and post-crash care services.

The TRMC was established in 2005 through the Road Traffic Management Corporation Act No. 20 of 1999.[131] The TRMC is legally mandated "To provide, in the public interest, for co-operative and coordinated strategic planning, regulation, facilitation and law enforcement in respect of road traffic matters by the national, provincial and local spheres of government; to regulate the contracting out of road traffic services; to provide for the phasing in of private investment in road traffic; to provide for connected matters" (p.1).[131] The aim of TRMC is "to promote safety, security, order, discipline and mobility on the roads, and to protect road infrastructure and the environment" (p. 1).[131]

The National Road Traffic Act governs law enforcement regarding road traffic matters No. 93 of 1996 and its amendments.[132,133] The Act covers registration and licensing of motor vehicles, manufacturers, builders and importers; driver's fitness testing and licensing; vehicle fitness testing and issuance of roadworthy certificate; operator fitness, registration and issuance of card; powers and functions of Director-General concerning road safety; appointment of dangerous goods inspector; road traffic signs and general speed limit; duties of drivers and garages concerning accidents and accident reports; and penalties for driving while under the influence of intoxicating liquor or drugs.[132,133] The TRMC has a critical role in preventing and curbing the incidence and severity of road traffic accidents through rigorous assurance of quality roads, the fitness of vehicles, and enforcement of the road traffic Act.

An assessment of the TRMC ten key performance indicators (KPI) in the 2015-2020 strategy revealed that only four (40%) were achieved.[134] That included: educating and creating awareness in road traffic matters, ensuring compliance with traffic legislation through effective and efficient enforcement, promoting the prevention of fraud and corruption in the road traffic fraternity, and creating a conducive environment by inculcating a culture of learning and high performance.[134] The two KPI's on establishing and sustaining relationships with interest groups on road traffic matters; and establishing an integrated national road traffic information system were partially achieved.[134] Lastly, the four KPI's on professionalising the road traffic fraternity, investing in road safety research and development, developing and monitoring norms and standards for the road traffic fraternity, and promoting and sourcing investment from the private sector for road safety were not achieved.[134]

The TRMC Strategic plan 2020/21 – 2024/2025 aims to achieve a 50% reduction in road fatalities from the 2018 base year and achieve a higher external and internal positive perception of the RTMC.[134] The TRMC planned activities would need to be complemented with health system investment to bridge the existing health service coverage and access gap of 20 points (i.e. out of a target of 100).[77] It is critically important to ensure that South Africa's health system (at national, provincial and district levels) can safeguard road accident victims' enjoyment of their constitutional right to emergency health services, including immediate post-accidence response, trauma care and rehabilitation services.

The development of the TRMC Strategic Plan was informed by the Brasilia Declaration on Road Safety[135] and the World Health Assembly Resolutions WHA69.7[136] and WHA57.10 on road safety.[137] The African Union Road Safety Charter[138] and the United Nations General Assembly Resolution A/RES/74/299 on improving global road safety[139] provides high-level political support for implementing TRMC Strategic Plan and health system strengthening of pre-hospital, hospital, post-hospital and reintegration services for road traffic accident victims.

LIMITATIONS

This study has some limitations inherent in DALY estimations and HCA employed in the monetization of DALYs. First, this study suffers shortcomings inherent in 2019 DALY estimations. The limitations in estimations of population and fertility are explained by Vollset et al.,[140] global diseases and injuries by GBD 2019 Diseases and Injuries Collaborators,[141] risk factors,[142] and demographics.[143]

Second, in his article entitled "Calculating the global burden of disease: time for a strategic reappraisal?" the late Professor Alan Williams argued that DALY estimates could not be used to monitor population health, to establish priorities between interventions, and to guide research priorities.[144] He argues that the information needed in priority setting is incremental gains and incremental costs associated with alternative health interventions in specific public health problems.

Third, GDP has been criticized for not taking into ac-

count negative externalities of the economic production process (e.g. pollution),[145] ignores distribution (or equity), ignores the contribution of housewives (full-time homemakers), and does not make people happier above a certain threshold of the higher material standard of living.[146–149]

Fourth, strictly applied, the human capital approach would value the DALYs accrued among children aged below 15 years, adults above retirement age (65 years and above), the unemployed, and persons who cannot work due to severe disablement at zero. That might consequently bias health development investments against these segments of society. Such discrimination would be going against South Africa's Constitution that proclaims every citizen right of access to health services, sufficient food, water, and social security[66]; the WHO Constitution[150]; and the United Nations Universal Declaration of Human Rights (UDHR)[151]. Therefore, to avoid contravening the South African Constitution, the WHO Constitution and the UDHR, we decided to value all the DALYs accruing to all age groups at the same net GDP per capita.

Fifth, our study is based on the monetary valuation of the DALYs incurred by South Africa in 2019. It does not capture the health impact of the global Coronavirus Disease (COVID-19) pandemic, whose spread to South Africa was confirmed on 5 March 2020.[152] By 24 July 2021, the country had conducted 14.5 million (equivalent to 24% of the population) COVID-19 tests that confirmed a total of 2.4 million cases, i.e. 2.2 million recovered cases, 144 thousand active cases, and 70 thousand deaths.[153] Therefore, the monetary value of DALY estimates and forecasts reported in this paper may be an underestimation.

CONCLUSION

The DALYs sustained had an estimated dollar value equal to 41% of South Africa's national GDP in 2019. Achievement of the SDG3 targets by 2030 would save the country DALYs worth Int$ 139.72 billion. In addition, adequate funding and implementation of existing health-related policies, legislations, strategies, and priority programmes plans might optimise national (including provincial and district) health system performance, and as a result, facilitate the bridging of extant gap in UHC service coverage index and subsequent attainment of SDG3 targets.

The evidence contained in this article can be used in two ways. First, inform the process of updating the expiring priority national programmatic strategic plans and advocacy for sufficient funding to tackle priority SDG-related health conditions. For example, the dollar value of DALYs could inform the revision of South Africa's Strategic Plan for the Prevention and Control of Non-Communicable Diseases, which expired in 2017.[154]

Second, in advocacy with both the Government and private sector to increase annual investment into the national health system from US$526 (in 2018) to US$984 per person (with 60% from general government expenditure on health) as proposed by Stenberg et al. for the attainment of SDG3.[19]

The dollar value of DALY estimates is intended purely for use in advocacy for increased funding into health-related sectors in pursuit of national and international health development goals.[65,66] There is an urgent need, where contextualized evidence does not exist, for economic evaluations of health promotion, disease prevention and control interventions to guide priority setting and decision-making in South Africa.

ACKNOWLEDGEMENTS

We owe profound gratitude to Jehovah Maccaddeshem for meeting all our needs in the entire process of writing this paper. The JoGHEP Editor and the two anonymous peer reviewers provided constructive suggestions that have been used to improve the quality of our paper. The views expressed are solely those of the authors and should not be attributed to their affiliated institutions.

AUTHOR CONTRIBUTIONS

FS, CH, and JMK designed the study; reviewed relevant literature; assembled data from IMF, IHME and WHO databases; developed dollar valuation model in Excel Sheets; analysed data; interpreted results, and drafted the manuscript. All authors approved the final version of the paper.

DECLARATION OF CONFLICTING INTERESTS

The authors completed the ICMJE Unified Competing Interest form (available upon request from the corresponding author), and declare no conflicts of interest

ETHICAL APPROVAL AND CONSENT TO PARTICIPATE

The analysis relied entirely on the secondary data published freely accessible international databases of the IHME, IMF, and WHO. Thus, ethical approval was not required.

FUNDING

The authors did not receive any financial support for the research, authorship, and publication of this paper.

AVAILABILITY OF DATA AND MATERIALS

The secondary data analysed in the course of this study is freely available from the following websites:

- GDP data from International Monetary Fund (IMF) World Economic Outlook Database database[1]: https://www.imf.org/en/Publications/WEO/weo-database/2020/October
- Current health expenditure per person data from World Health Organization (WHO) Global Health Expenditure Database[18]: http://apps.who.int/nha/database/Select/Indicators/en
- DALY data from the Institute for Health Metrics and Evaluation (IHME) database[3]: http://ghdx.healthdata.org/gbd-results-tool

CORRESPONDENCE

Joses Muthuri Kirigia, ASDRC
P.O. Box 699400100, Nairobi, Kenya

Email: muthurijoses68@gmail.com.
Tel: +254 720 664 167.

Submitted: July 09, 2021 CEST, Accepted: July 29, 2021 CEST

REFERENCES

1. World Economic Outlook Database [database online]. International Monetary Fund (IMF). https://www.imf.org/en/Publications/WEO/weo-database/2020/October. Published October 2020. Accessed March 23, 2020.

2. United Nations Development Programme (UNDP). *Human Development Report 2020. The next Frontier: Human Development and the Anthropocene*. New York: UNDP; 2020.

3. Global Burden of Disease Collaborative Network. *Global Burden of Disease Study 2019 (GBD 2019) Results*. Seattle, United States: Institute for Health Metrics and Evaluation (IHME); 2020. http://ghdx.healthdata.org/gbd-results-tool. Accessed February 1, 2020.

4. Ataguba JE, Day C, McIntyre D. Monitoring and Evaluating Progress towards Universal Health Coverage in South Africa. *PLoS Med*. 2014;11(9):e1001686. doi:10.1371/journal.pmed.1001686

5. Ataguba JE, McIntyre D. Paying for and receiving benefits from health services in South Africa: is the health system equitable? *Health Policy Plan*. 2012;27(Suppl 1):i35-i45. doi:10.1093/heapol/czs005

6. Coovadia H, Jewkes R, Barron P, Sanders D, McIntyre D. The health and health system of South Africa: historical roots of current public health challenges. *Lancet*. 2009;374(9692):817-834. doi:10.1016/s0140-6736(09)60951-x

7. Massyn N, Pillay Y, Padarath A, eds. District Health Barometer 2017/2018. Durban: Health Systems Trust; 2019. https://www.hst.org.za/publications/District%20Health%20Barometers/DHB+2017-18+Web+8+Apr+2019.pdf. Accessed May 25, 2021.

8. Mash R, Von Pressentin KB. Strengthening the district health system through family physicians. In: Rispel LC, Padarath A, eds. *S. Afr. Health Rev 2018*. Durban: Health Systems Trust; 2018:33-40. https://www.hst.org.za/publications/South%20African%20Health%20Reviews/SAHR%202018.pdf. Accessed May 20, 2021.

9. Schneider H, Daviaoud E, Besoda D, Rohdes S, Sanders D. Ward-based primary health care outreach teams in South Africa: developments, challenges and future directions. In: Rispel LC, Padarath A, eds. *S. Afr. Health Rev 2018*. Durban: Health Systems Trust; 2018:59-66. https://www.hst.org.za/publications/South%20African%20Health%20Reviews/SAHR%202018.pdf. Accessed May 20, 2021.

10. Rispel LC, Blaauw D, Ditlopo P, White J. Human resources for health and universal health coverage: progress, complexities and contestations. In: Rispel LC, Padarath A, eds. *S. Afr. Health Rev 2018*. Durban: Health Systems Trust; 2018:13-22. https://www.hst.org.za/publications/South%20African%20Health%20Reviews/SAHR%202018.pdf. Accessed May 20, 2021.

11. World Health Organisation (WHO). *World Health Statistics 2020: Monitoring Health for the SDGs, Sustainable Development Goals*. Geneva: WHO; 2020.

12. Commission on Social Determinants of Health (CSDH). *Closing the Gap in a Generation: Health Equity through Action on the Social Determinants of Health. Final Report of the Commission on Social Determinants of Health*. Geneva: World Health Organization; 2008.

13. World Health Organization (WHO). *World Health Statistics 2017: Monitoring Health for the SDGs, Sustainable Development Goals*. Geneva: WHO; 2017.

14. Selebalo H, Webster D. Monitoring the right of access to adequate housing in South Africa. Working Paper 16. Pretoria: Studies in Poverty and Inequality Institute (SPII); 2017. https://vulekamali.gov.za/datasets/contributed/monitoring-the-right-of-access-to-adequate-housing-in-south-africa. Published January 24, 2018. Accessed May 15, 2021.

15. *Crime Situation in Republic of South Africa Twelve Months 01 April 2017 to 31 March 2018*. South African Government https://www.gov.za/sites/default/files/gcis_document/201809/crime-stats201718.pdf. Accessed March 12, 2021.

16. Kirigia JM, Ota MO, Senkubuge F, Wiysonge CS, Mayosi BM. Developing the African national health research systems barometer. *Health Res Policy Sys*. 2016;14(1):53. doi:10.1186/s12961-016-0121-4

17. Senkubuge F, Muthivhi T, Loots G, et al. Status of South Africa's National Health Research System: a 2018 update. In: Rispel LC, Padarath A, eds. *S Afr Health Rev 2018*. Durban: Health Systems Trust; 2018:125-134. https://www.hst.org.za/publications/South%20African%20Health%20Reviews/SAHR%202018.pdf. Accessed May 20, 2021.

18. Indicators and data. In: *Global Health Expenditure Database [database online]*. World Health Organization. http://apps.who.int/nha/database/Select/Indicators/en. Accessed March 10, 2021.

19. Stenberg K, Hanssen O, Edejer TTT, et al. Financing transformative health systems towards achievement of the health Sustainable Development Goals: a model for projected resource needs in 67 low-income and middle-income countries. *Lancet Glob Health*. 2017;5(9):e875-e887. doi:10.1016/s2214-109x(17)30263-2

20. Ataguba JE, Akazili J, McIntyre D. Socioeconomic-related health inequality in South Africa: evidence from General Household Surveys. *Int J Equity Health*. 2011;10(1):48. doi:10.1186/1475-9276-10-48

21. McIntyre D, Mooney G. Equity and health systems. In: McIntyre D, Mooney G, eds. *The Economics of Health Equity*. London: Cambridge University Press; 2007:149-150. https://doi.org/10.1017/cbo9780511544460.

22. Kirigia JM. *Efficiency of Health System Units in Africa: A Data Envelopment Analysis*. Nairobi: University of Nairobi Press; 2013.

23. Mbonigaba J, Oumar SB. The relative efficiency of South African municipalities in providing public health care. *Afr J Econ Manag Stud*. 2016;7(3):346-365. doi:10.1108/ajems-04-2014-0028

24. Kinfu Y. The efficiency of the health system in South Africa: evidence from stochastic frontier analysis. *Appl Econ*. 2013;45(8):1003-1010. doi:10.1080/00036846.2011.613787

25. Kirigia JM, Mburugu GN. The monetary value of human lives lost due to neglected tropical diseases in Africa. *Infect Dis Poverty*. 2017;6(1):165. doi:10.1186/s40249-017-0379-y

26. Kirigia JM, Muthuri RDK, Nabyonga-Orem J, Kirigia DG. Counting the cost of child mortality in the World Health Organization African region. *BMC Public Health*. 2015;6(15):1103. doi:10.1186/s12889-015-2465-z

27. Kirigia JM, Mwabu GM, Orem JN, Muthuri RDK. Indirect cost of maternal deaths in the WHO African Region in 2010. *BMC Pregnancy Childbirth*. 2014;14(1):299. doi:10.1186/1471-2393-14-299

28. Kirigia JM, Mwabu GM. The Monetary Value of Disability-Adjusted-Life-Years Lost in the East African Community in 2015. *Modern Economy*. 2018;9(7):1360-1377. doi:10.4236/me.2018.97087

29. Lenk EJ, Redekop WK, Luyendijk M, Rijnsburger AJ, Severens JL. Productivity Loss Related to Neglected Tropical Diseases Eligible for Preventive Chemotherapy: A Systematic Literature Review. Gray DJ, ed. *PLoS Negl Trop Dis*. 2016;10(2):e0004397. doi:10.1371/journal.pntd.0004397

30. Naidoo KS, Fricke TR, Frick KD, et al. Potential Lost Productivity Resulting from the Global Burden of Myopia: Systematic Review, Meta-analysis, and Modelling. *Ophthalmology*. 2019;126(3):338-346. doi:10.1016/j.ophtha.2018.10.029

31. Suh M, Kang DR, Lee DH, et al. Socioeconomic Burden of Influenza in the Republic of Korea, 2007–2010. Drews SJ, ed. *PLoS ONE*. 2013;8(12):e84121. doi:10.1371/journal.pone.0084121

32. Igarashi A, Fukuchi Y, Hirata K, et al. COPD uncovered: a cross-sectional study to assess the socioeconomic burden of COPD in Japan. *Int J Chron Obstruct Pulmon Dis*. 2018;13:2629-2641. doi:10.2147/copd.s167476

33. Muthuri RDK, Muthuri NG, Kirigia JM. Pecuniary Value of Disability-Adjusted-Life-Years in the Arab Maghreb Union in 2015. *J Hum Resource Sustain Stud*. 2018;6(4):249-274. doi:10.4236/jhrss.2018.64041

34. Al-Kaabi SK, Atherton A. Impact of noncommunicable diseases in the State of Qatar. *Clinicoecon Outcomes Res*. 2015;7:377-385. doi:10.2147/ceor.s74682

35. Estes C, Abdel-Kareem M, Abdel-Razek W, et al. Economic burden of hepatitis C in Egypt: the future impact of highly effective therapies. *Aliment Pharmacol Ther*. 2015;42(6):696-706. doi:10.1111/apt.13316

36. Gordois AL, Proudfoot EM, Paoli CJ, Gandra SR. Systematic review of productivity losses associated with cardiovascular disease in Europe. *Value Health*. 2015;18(7):A396. doi:10.1016/j.jval.2015.09.897

37. Gordois AL, Toth PP, Quek RGW, Proudfoot EM, Paoli CJP, Gandra SR. Productivity losses associated with cardiovascular disease: a systematic review. *Expert Rev Pharm Out*. 2016;16(6):759-769. doi:10.1080/14737167.2016.1259571

38. Fasseeh A, Németh B, Molnár A, et al. A systematic review of the indirect costs of schizophrenia in Europe. *Eur J Public Health*. 2018;28(6):1043-1049. doi:10.1093/eurpub/cky231

39. Diel R, Vandeputte J, de Vries G, Stillo J, Wanlin M, Nienhaus A. Costs of tuberculosis disease in the European Union: a systematic analysis and cost calculation. *Eur Respir J*. 2014;43(2):554-565. doi:10.1183/09031936.00079413

40. Bolin K. Physical inactivity: productivity losses and healthcare costs 2002 and 2016 in Sweden. *BMJ Open Sport Exerc Med*. 2018;4(1):e000451. doi:10.1136/bmjsem-2018-000451

41. Luengo-Fernandez R, Leal J, Gray A, Sullivan R. Economic burden of cancer across the European Union: a population-based cost analysis. *Lancet Oncol*. 2013;14(2):1165-1174. doi:10.1016/s1470-2045(13)70442-x

42. Adelman G, Rane SG, Villa KF. The cost burden of multiple sclerosis in the United States: a systematic review of the literature. *J Med Econ*. 2013;16(5):639-647. doi:10.3111/13696998.2013.778268

43. Chen S, Kuhn M, Prettner K, Bloom DE. The macroeconomic burden of noncommunicable diseases in the United States: Estimates and projections. Husain MJ, ed. *PLoS ONE*. 2018;13(11):e0206702. doi:10.1371/journal.pone.0206702

44. Her Majesty the Queen in Right of Canada. *Economic Burden of Illness in Canada, 2005–2008*. Toronto: Public Health Agency of Canada; 2014.

45. Rice DP, Hodgson TA, Kopstein AN. The economic costs of illness: a replication and update. *Health Care Financ Rev*. 1985;7(1):61-80.

46. Laserna A, Barahona-Correa J, Baquero L, Castañeda-Cardona C, Rosselli D. Economic impact of dengue fever in Latin America and the Caribbean: a systematic review. *Pan Am J Public Health*. 2018;42:e111. doi:10.26633/rpsp.2018.111

47. Romano M, Machnicki G, Rojas JI, Frider N, Correale J. There is much to be learnt about the costs of multiple sclerosis in Latin America. *Arq Neuropsiquiatr*. 2013;71(8):549-555. doi:10.1590/0004-282x20130082

48. Bahia L, Toscano CM, Takemoto MLS, Araujo DV. Systematic review of pneumococcal disease costs and productivity loss studies in Latin America and the Caribbean. *Vaccine*. 2013;31(Suppl 3):C33-C44. doi:10.1016/j.vaccine.2013.05.030

49. Takemoto MLS, Bahia L, Toscano CM, Araujo DV. Systematic review of studies on rotavirus disease cost-of-illness and productivity loss in Latin America and the Caribbean. *Vaccine*. 2013;31(Suppl 3):C45-C57. doi:10.1016/j.vaccine.2013.05.031

50. Murray CJ. Quantifying the burden of disease: the technical basis for disability-adjusted life years. *Bull World Health Organ*. 1994;72(3):429-445.

51. Vos T, Lim SS, Abbafati C, et al. Global burden of 369 diseases and injuries in 204 countries and territories, 1990–2019: a systematic analysis for the Global Burden of Disease Study 2019. *Lancet*. 2020;396(10258):1204-1222. doi:10.1016/s0140-6736(20)30925-9

52. Organization for Economic Cooperation and Development (OECD). *The Role of Human and Social Capital*. Paris: OECD; 2001.

53. Suhrcke M, de Paz Nieves C. *The Impact of Health and Health Behaviours on Educational Outcomes in High-Income Countries: A Review of the Evidence*. Copenhagen: WHO Regional Office for Europe; 2011.

54. Gondek D, Ning K, Ploubidis GB, Nasim B, Goodman A. The impact of health on economic and social outcomes in the United Kingdom: A scoping literature review. *PLoS ONE*. 2018;13(12):e0209659. doi:10.1371/journal.pone.0209659

55. Ezeamama AE, Bustinduy AL, Nkwata AK, et al. Cognitive deficits and educational loss in children with schistosome infection: A systematic review and meta-analysis. *PLOS Negl Trop Dis*. 2018;12(1):e0005524. doi:10.1371/journal.pntd.0005524

56. Behrman JR. The impact of health and nutrition on education. *World Bank Res Obs*. 1996;11(1):25-37. doi:10.1093/wbro/11.1.23

57. Glewwe P. The impact of child health and nutrition on education in developing countries: Theory, econometric issues, and recent empirical evidence. *Food Nutr Bull*. 2005;26(2 Suppl 2):S235-S250. doi:10.1177/15648265050262s215

58. Barbaresi WJ, Katusic SK, Colligan RC, Weaver AL, Jacobsen SJ. Long-term school outcomes for children with attention-deficit/hyperactivity disorder: a population-based perspective. *J Dev Behav Pediatr*. 2007;28(4):265-273. doi:10.1097/dbp.0b013e31811ff87d

59. Westerlund J, Holmberg K, Fernell E. Academic performance of adolescents with ADHD and other behavioural and learning problems— a population-based longitudinal study. *Acta Paediatr*. 2011;100(3):402-406. doi:10.1111/j.1651-2227.2010.02048.x

60. Case A, Fertig A, Paxson C. The lasting impact of childhood health and circumstance. *J Health Econ*. 2005;24(2):365-389. doi:10.1016/j.jhealeco.2004.09.008

61. Bloom DE, Canning D, Sevilla J. The Effect of Health on Economic Growth: A Production Function Approach. *World Dev*. 2004;32(1):1-13. doi:10.1016/j.worlddev.2003.07.002

62. Commission on Macroeconomics and Health. *Macroeconomics and Health: Investing in Health for Economic Development. Report of the Commission on Macroeconomics and Health*. Geneva: World Health Organization; 2001.

63. Kirigia JM, Mwabu GM. Haemorrhage of Gross Domestic Product from Disability-Adjusted-Life-Years Among 15-59 Year Olds in Kenya. *Int Arch Med*. 2018;11(20). doi:10.3823/2561

64. Kirigia JM, Mburugu GN, Huka GS. The Indirect Cost of Disability Adjusted Life Years Lost among the Elderly in Kenya. *Int Arch Med*. 2017;10(213). doi:10.3823/2483

65. United Nations (UN). Transforming our world: the 2030 Agenda for Sustainable Development. Seventieth session of the United Nations General Assembly Resolution A/RES/70/1. New York: UN; 2015.

66. Republic of South Africa. *Strategic Plan 2020/21-2024/25*. Pretoria: Department of Health; 2020.

67. World Health Organization (WHO). *Global Health Sector Strategy on HIV 2016-2021: Towards Ending AIDS. The Sixty-Ninth World Health Assembly Document A69/31*. Geneva: WHO; 2016.

68. World Health Organization (WHO). *World Malaria Report 2020: 20 Years of Global Progress and Challenges*. Geneva: WHO; 2020.

69. World Health Organization (WHO). *Global Technical Strategy for Malaria 2016-2030*. Geneva: WHO; 2015.

70. World Health Organization (WHO). *Global Tuberculosis Report 2020*. Geneva: WHO; 2020.

71. World Health Organization (WHO). *The End TB Strategy*. Geneva: WHO; 2015.

72. World Health Organization (WHO). *Global Vector Control Response 2017–2030*. Geneva: WHO; 2017.

73. World Health Organization (WHO). *Global Health Sector Strategy on Viral Hepatitis 2016–2021: Towards Ending Viral Hepatitis*. Geneva: WHO; 2016.

74. World Health Organization (WHO). *Progress Report on HIV, Viral Hepatitis and Sexually Transmitted Infections, 2019. Web Annex 1. Key Data at a Glance*. Geneva: WHO; 2019.

75. Muthuri RNDK, Kirigia JM. The monetary value of disability-adjusted life years lost in Kenya in 2017. *Sage Open*. 2020;10(4):1-15. doi:10.1177/2158244020970556

76. International Labour Organization (ILO). *Ratifications of C138 - Minimum Age Convention, 1973 (No. 138)*. Geneva: ILO; 1973.

77. Index of service coverage data by country. In: *Global Health Observatory Data Repository [Database Online]*. World Health Organization. https://apps.who.int/gho/data/view.main.INDEXOFESSENTIALSERVICECOVERAGEv?lang=en. Accessed February 22, 2020.

78. World Health Organization Regional Office for Africa (WHO/AFRO). *Road Map for Accelerating the Attainment of the MDGs Related to Maternal and Newborn Health in Africa*. Brazzaville: WHO/AFRO; 2004.

79. Every Woman Every Child. The global strategy for women's, children's and adolescents' health (2016-2030): survive, thrive, and transform. https://www.everywomaneverychild.org/wp-content/uploads/2017/10/EWEC_GSUpdate_Full_EN_2017_web-1.pdf. Published 2015. Accessed February 22, 2021.

80. Every Woman Every Child. Operational framework for the global strategy for women's, children's and adolescents' health. https://www.everywomaneverychild.org/wp-content/uploads/2017/10/EWEC_OpFramework_Full_EN_2017_web-1.pdf. Published 2016. Accessed February 22, 2021.

81. World Health Organization (WHO). *Committing to Implementation of the Global Strategy for Women's, Children's and Adolescents' Health. World Health Assembly Resolution WHA69.2*. Geneva: WHO; 2016.

82. World Health Organization (WHO). *WHA71.9 Infant and Young Child Feeding. Resolution WHA71.9*. Geneva: WHO; 2018.

83. World Health Organization (WHO). *Maternal, Infant and Young Child Nutrition. Resolution WHA65.6*. Geneva: WHO; 2012.

84. World Health Organization (WHO). *Female Genital Mutilation. Resolution WHA61.16*. Geneva: WHO; 2008.

85. World Health Organization (WHO). *Global Vaccine Action Plan. Resolution WHA68.6*. Geneva: WHO; 2015.

86. World Health Organization (WHO). *Strengthening Immunization to Achieve the Goals of the Global Vaccine Action Plan. Resolution WHA70.14*. Geneva: WHO; 2017.

87. World Health Organization (WHO). *Global Plan of Action to Strengthen the Role of the Health System within a National Multisectoral Response to Address Interpersonal Violence, in Particular against Women and Girls, and against Children. World Health Assembly Resolution WHA69.5*. Geneva: WHO; 2016.

88. World Health Organization (WHO). *Newborn Health: Action Plan. Resolution WHA67.10*. Geneva: WHO; 2014.

89. World Health Organization (WHO). *Global Immunization Strategy. Resolution WHA61.15*. Geneva: WHO; 2008.

90. World Health Organization (WHO). *Implementation of the Recommendations of the United Nations Commission on Life-Saving Commodities for Women and Children. Resolution WHA66.7*. Geneva: WHO; 2013.

91. World Health Organization (WHO). *Working towards the Reduction of Perinatal and Neonatal Mortality. Resolution WHA64.13*. Geneva: WHO; 2011.

92. Republic of South Africa. *The South African Constitution and Bill of Rights*. Pretoria: Department of Justice; 1996.

93. Republic of South Africa. *National Health Act No. 61 of 2003*. Pretoria: Republic of South Africa; 2003.

94. Republic of South Africa. *Choice on Termination of Pregnancy Act No. 92 of 1996*. Pretoria: Republic of South Africa; 1996.

95. Republic of South Africa. *National Health Insurance Bill*. Pretoria: Republic of South Africa; 2019.

96. African Union (AU). *Declaration on Ending Preventable Child and Maternal Death in Africa – Doc. Assembly/AU/18(XXIII) Add.3. Decision Assembly/AU/Decl.2(XXIII)*. Addis Ababa: AU; 2014.

97. African Union (AU). *Protocol to the African Charter on Human and People's Rights on the Rights of Women in Africa*. Addis Ababa: AU; 2003.

98. Organization of African Unity (OAU). *African Charter on the Rights and Welfare of the Child. Adopted by the 26th Ordinary Session of the Assembly of Heads of State and Government of the OAU*. Addis Ababa: OAU; 1990.

99. United Nations (UN). *Intensification of Efforts to Prevent and Eliminate All Forms of Violence against Women and Girls. General Assembly Resolution A/RES/75/161*. New York: UN; 2020.

100. United Nations (UN). *Intensifying Global Efforts for the Elimination of Female Genital Mutilation. General Assembly Resolution A/RES/75/160*. New York: UN; 2020.

101. United Nations (UN). *Intensification of Efforts to End Obstetric Fistula. General Assembly Resolution A/RES/75/159*. New York: UN; 2020.

102. United Nations (UN). *Political Declaration of the High-Level Meeting Universal Health Coverage. General Assembly Resolution A/RES/74/2*. New York: UN; 2019.

103. United Nations (UN). *Rights of the Child. General Assembly Resolution A/RES/71/177*. New York: UN; 2017.

104. United Nations (UN). *Preventable Maternal Mortality and Morbidity and Human Rights. General Assembly Resolution A/HRC/33/L.3/Rev.1*. New York: UN; 2016.

105. World Health Organization (WHO). *Global Health Sector Strategies on HIV, Viral Hepatitis and Sexually Transmitted Infections, for the Period 2016–2021. Resolution WHA69.22*. Geneva: WHO; 2016.

106. World Health Organization (WHO). *Global Strategy and Targets for Tuberculosis Prevention, Care and Control after 2015. Resolution WHA67.1*. Geneva: WHO; 2014.

107. World Health Organization (WHO). *Global Technical Strategy and Targets for Malaria 2016–2030. Resolution WHA68.2*. Geneva: WHO; 2015.

108. World Health Organization (WHO). *Global Vector Control Response: An Integrated Approach for the Control of Vector-Borne Diseases. Resolution. WHA70.16.* Geneva: WHO; 2016.

109. World Health Organization (WHO). *Water, Sanitation and Hygiene in Health Care Facilities. WHA Resolution WHA72.7*. Geneva: WHO; 2019.

110. African Union (AU). *Africa Health Strategy 2016-2030*. Addis Ababa: AU; 2015.

111. African Union (AU). *Agenda 2063: The Africa We Want*. Addis Ababa: African Union Commission; 2015.

112. African Union (AU). *Decision on the Report of the Commission on Development of the African Union Agenda 2063 and the Report of the Ministerial Follow-Up Committee on The Bahr Dar Retreat - Doc. Assembly/AU/5(XXIV). Decision Assembly/AU/Dec.565(XXIV)*. Addis Ababa: AU; 2015.

113. African Union (AU). *Decision on the Domestication of the First Ten-Year Implementation Plan of Agenda 2063 - Doc. EX.CL/931(XXVIII). Decision Assembly/AU/Dec.588(XXVI)*. Addis Ababa: AU; 2016.

114. African Union (AU). *Decision on the Establishment of the African Centre of Disease Control and Prevention (African CDC) Doc. Assembly/AU/4(XXIV). Decision Assembly/AU/Dec.554(XXIV)*. Addis Ababa: AU; 2015.

115. African Union (AU). *Declaration of the Special Summit of African Union on HIV/AIDS, Tuberculosis and Malaria. Abuja Actions toward the Elimination of HIV and AIDS, Tuberculosis and Malaria in Africa by 2030. Abuja, Nigeria, 16 July 2013*. Addis Ababa: AU; 2013.

116. United Nations (UN). *Political Declaration of the High-Level Meeting Universal Health Coverage. General Assembly Resolution A/RES/74/2*. New York: UN; 2019.

117. United Nations (UN). *Consolidating Gains and Accelerating Efforts to Control and Eliminate Malaria in Developing Countries, Particularly in Africa, by 2030. General Assembly Resolution A/RES/74/305*. New York: UN; 2020.

118. United Nations (UN). *Political Declaration of the High-Level Meeting of the General Assembly on the Fight against Tuberculosis. General Assembly Resolution A/RES/73/3*. New York: UN; 2018.

119. United Nations (UN). *Political Declaration of the High-Level Meeting of the General Assembly on Antimicrobial Resistance. General Assembly Resolution A/RES/71/3*. New York: UN; 2016.

120. World Health Organization (WHO). *WHA71.6 WHO's Global Action Plan on Physical Activity 2018–2030. WHA Resolution WHA71.6*. Geneva: WHO; 2018.

121. World Health Organization (WHO). *Global Strategy on Diet, Physical Activity and Health. Resolution WHA57.17*. Geneva: WHO; 2004.

122. World Health Organization (WHO). *Follow-up to the Political Declaration of the High-Level Meeting of the General Assembly on the Prevention and Control of Noncommunicable Diseases. Resolution WHA66.10*. Geneva: WHO; 2013.

123. World Health Organization (WHO). *Global Strategy for the Prevention and Control of Noncommunicable Diseases. Resolution WHA 53.14*. Geneva: WHO; 2000.

124. World Health Organization (WHO). *Comprehensive Mental Health Action Plan 2013–2020. Resolution WHA66.8*. Geneva: WHO; 2013.

125. World Health Organization (WHO). *WHO Framework Convention on Tobacco Control. Resolution WHA56.1*. Geneva: WHO; 2005.

126. African Union (AU), World Health Organization (WHO). *AUC-WHO/COM.3/2014: Commitment on Noncommunicable Diseases in Africa – Policies and Strategies to Address Risk Factors. The First Meeting of African Ministers of Health Jointly Convened by the AUC and WHO, Luanda, Angola, 16–17 April 2014*. Addis Ababa: AU; 2014.

127. United Nations (UN). *Political Declaration of the High-Level Meeting Universal Health Coverage. General Assembly Resolution A/RES/74/2*. New York: UN; 2019.

128. United Nations (UN). *Political Declaration of the High-Level Meeting of the General Assembly on the Prevention and Control of Noncommunicable Diseases. Resolution A/RES/66/2*. New York: UN; 2012.

129. United Nations (UN). *Political Declaration of the Third High-Level Meeting of the General Assembly on the Prevention and Control of Noncommunicable Diseases. General Assembly Resolution A/RES/73/2*. New York: UN; 2018.

130. United Nations (UN). *International Year of Fruits and Vegetables, 2021. General Assembly Resolution A/RES/74/244*. New York: UN; 2020.

131. Republic of South Africa. *Road Traffic Management Corporation Act No. 20 of 1999*. Cape Town: Republic of South Africa; 1999.

132. Republic of South Africa. *National Road Traffic Act No. 93 of 1996*. Cape Town: Republic of South Africa; 1996.

133. Republic of South Africa. *National Road Traffic Amendment Act No. 64 of 2008*. Cape Town: Republic of South Africa; 2008.

134. Republic of South Africa. *Strategic Plan 2020/21 – 2024/2025. Safe Roads in South Africa*. Pretoria: Road Traffic Management Corporation; 2020.

135. World Health Organization (WHO). *Brasilia Declaration. Second Global High-Level Conference on Road Safety: Time for Results. Brasilia, 18 and 19 November 2015*. Brasilia: WHO; 2015.

136. World Health Organization (WHO). *Addressing the Challenges of the United Nations Decade of Action for Road Safety (2011–2020): Outcome of the Second Global High-Level Conference on Road Safety – Time for Results. World Health Assembly Resolution WHA69.7*. Geneva: WHO; 2016.

137. World Health Organization (WHO). *Road Safety and Health. Resolution WHA57.10*. Geneva: WHO; 2004.

138. African Union (UN). *African Road Safety Charter. Adopted by the Assembly of the Union Twenty-Sixth Ordinary Session 30 - 31 January 2016 Addis Ababa, Ethiopia*. Addis Ababa: AU; 2016.

139. United Nations (UN). *Improving Global Road Safety. General Assembly Resolution A/RES/74/299*. New York: UN; 2020.

140. Vollset SE, Goren E, Yuan C-W, et al. Fertility, mortality, migration, and population scenarios for 195 countries and territories from 2017 to 2100: a forecasting analysis for the Global Burden of Disease Study. *Lancet*. 2020;396(10258):1285-1306. doi:10.1016/s0140-6736(20)30677-2

141. Vos T, Lim SS, Abbafati C, et al. Global burden of 369 diseases and injuries, 1990–2019: a systematic analysis for the Global Burden of Disease Study 2019. *Lancet*. 2020;396(10258):1204-1222. doi:10.1016/s0140-6736(20)30925-9

142. Murray CJL, Aravkin AY, Zheng P, et al. Global burden of 87 risk factors in 204 countries and territories, 1990–2019: a systematic analysis for the Global Burden of Disease Study 2019. *Lancet*. 2020;396(10258):1223-1249. doi:10.1016/s0140-6736(20)30752-2

143. Wang H, Abbas KM, Abbasifard M, et al. Global age-sex-specific fertility, mortality, healthy life expectancy (HALE), and population estimates in 204 countries and territories, 1950–2019: a comprehensive demographic analysis for the Global Burden of Disease Study 2019. *Lancet*. 2020;396(10258):1160-1203. doi:10.1016/s0140-6736(20)30977-6

144. Williams A. Calculating the global burden of disease: time for a strategic reappraisal? *Health Econ*. 1999;8(1):1-8. https://doi.org/10.1002/(SICI)1099-1050(199902)8:1%3c1::AID-HEC399%3e3.0.CO;2-B.

145. Giannetti BF, Agostinho F, Almeida CMVB, Huisingh D. A review of limitations of GDP and alternative indices to monitor human wellbeing and to manage eco-system functionality. *J Clean Prod*. 2015;87:11-25. doi:10.1016/j.jclepro.2014.10.051

146. Cole A. The Politics of Happiness. *AQ: Australian Quarterly*. 2006;78(5):21-24. doi:10.2307/20638424

147. Fleurbaey M. Beyond GDP: The Quest for a Measure of Social Welfare. *J Econ Lit*. 2009;47(4):1029-1075. doi:10.1257/jel.47.4.1029

148. Stiglitz J, Sen A, Fitoussi J-P. *Report by the Commission on the Measurement of Economic Performance and Social Progress*. Paris: Commission on the Measurement of Economic Performance and Social Progress; 2009.

149. Kahneman D, Deaton A. High income improves evaluation of life but not emotional well-being. *PNAS*. 2010;107(38):16489-16493. doi:10.1073/pnas.1011492107

150. WHO. *Basic Documents, Forty-Fifth Edition, Supplement, October 2006*. Geneva: WHO; 2006.

151. United Nations (UN). *International Bill of Human Rights: A Universal Declaration of Human Rights. General Assembly Resolution A/RES/217(III)*. New York: UN; 1948.

152. Minister Zweli Mkhize reports first case of COVID-19 Coronavirus. South African Department of Health. https://www.gov.za/speeches/health-reports-first-case-covid-19-coronavirus-5-mar-2020-0000. Published March 5, 2020. Accessed July 24, 2021.

153. COVID-19 Coronavirus Pandemic [database online]. Worldometer. https://www.worldometers.info/coronavirus/#countries. Published July 27, 2021. Accessed July 27, 2021.

154. Republic of South Africa. *Strategic Plan for the Prevention and Control of Non-Communicable Diseases 2013-17*. Pretoria: Department of Health; 2013.