

ORIGINAL ARTICLE

Discounted monetary value of human lives lost during the mass demonstrations in Khartoum State, Sudan, 2022

HUDA MOHAMED MUKHTAR AHMED*¹, IBTISAM SATTI IBRAHIM IDRIS², MAZIN FIKRI MOHAMED OSMAN³

AFFILIATIONS:

¹Department of Econometrics and Social Statistics, Faculty of Economic and Social Studies, University of Khartoum, Sudan

²Department of Sociology and Social Anthropology, Faculty of Economic and Social Studies, University of Khartoum, Sudan

³Central Bureau of Statistics, Khartoum, Sudan

CORRESPONDENCE:

Huda Mohamed Mukhtar Ahmed

¹Department of Econometrics and Social Statistics, Faculty of Economic and Social Studies, University of Khartoum, Sudan.
Email: haudashalaby@gmail.com
ORCID ID: 0000 - 0003 - 4706 – 6800

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ABSTRACT

BACKGROUND:

Sudan is rich in natural resources and diverse climate but faces significant food insecurity. The country's challenges stem from prolonged civil wars and economic decline after South Sudan's secession, leading to political instability and uprisings. The human cost has been devastating, with millions killed or affected by violence, displacement, and infrastructure destruction.

OBJECTIVE:

This paper aimed to estimate the total discounted value of 112 human lives lost during peaceful demonstrations in Khartoum State in 2022.

METHODS:

Data collected by the Doctors' Committee from Oct 2021 to Oct 2023 was used. The Human Capital approach (HCA) estimated the total discounted value of human lives lost using a 3% discount rate and the national life expectancy in 2022 as 65.86. Sensitivity analysis tested the robustness of the results. The model was re-estimated using 5% and 10% discount rates and global and Sub-Saharan life expectancies.

RESULTS:

Human lives lost had a total discounted value of \$1,871,745 and an average value of \$136,816 per life. Recalculating the total discounted value of human lives lost (TDVHL) using higher rates, 5% and 10%, reduced the values by \$499,516 (26.7%) and \$1,094,609 (58.5%), respectively. Using Sub-Saharan life expectancy reduced the TDVHL by \$105,821 (5.7%), while the global life expectancy increased it by \$130,992 (7.0%). About 82% of the TDVHL was shared by dead persons aged 15-29. The average value per dead person decreased with age. The average for the 14-19 age group was almost four times that of the 55-59 group.

CONCLUSION:

The study reveals the high economic cost of premature deaths from mass demonstrations in Khartoum State, stressing the need for policies protecting young people and promoting stability to drive economic growth and sustainable development

KEYWORDS:

Human Capital Approach, Life expectancy, Dead persons, Mass demonstrations, Sensitivity analysis, Total discounted value of human lives lost

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INTRODUCTION

Sudan, situated in Northeast Africa, is bordered by seven countries and ranks as the third-largest country by area in both Africa and the Arab world. As of 2022, its population was estimated at 45.7 million¹. Sudan is endowed with abundant natural resources and a diverse climate, featuring the Nile River, the longest river in the world, and approximately 21 million hectares of arable land. Additionally, it has the largest livestock population in Africa, positioning it as a potential global food basket².

Despite its advantages, Sudan faces significant challenges in feeding its population, with about 34% of the population being food insecure in 2022¹. The country's difficulties arise from prolonged civil wars in the north and south, as well as in Darfur, Blue Nile, and South Kordofan. The human toll of these conflicts was devastating, with approximately 200,000 to 400,000 people estimated to be killed in Darfur³ and up to two million killed in the north-south wars, culminating in the secession of South Sudan in 2011. This secession caused a major loss of oil revenue, which previously accounted for 95% of Sudan's exports and 50% of government revenue¹. The subsequent economic decline involved reduced growth, persistent inflation, and a weakening national currency, exacerbated by an influx of refugees from South Sudan and neighboring countries.

The economic crisis has driven political instability and uprisings, especially in underserved regions like Darfur, Blue Nile, and South Kordofan. In 2018, widespread economic hardship sparked mass demonstrations that led to the overthrow of the Thirty Years of Ingaz regime. A Transitional Governmental Desk, comprising civilians and military generals, was established to steer Sudan towards democracy. However, internal conflicts within the transitional government led to a military coup against civilian partners. There was immediate resistance to the coup, resulting in a resurgence of mass demonstrations in Khartoum State. Political instability and uprisings persisted for an entire year, during which 113 persons were killed. The demonstrations continued until the start of the latest war in 2023. The loss of human lives since the December revolution has been immense: approximately 246 people died in Khartoum State

during the 2018-2019 uprisings, and 127 were killed in the crackdown on the sit-in outside the Military General Command. No further information on the ages and causes of death is available. The lack of detailed demographic data of the deceased, makes it difficult to estimate the resulting potential years of life lost.

Though conflict obviously causes deaths and injuries on the battlefield, it also leads to health consequences from the displacement of populations, the breakdown of health and social services, and the heightened risk of disease transmission⁴. While many studies focus on the public health impacts of diseases⁵⁻⁸, research on the mortality and morbidity effects of wars and conflicts is limited, partly due to scarce data in civil registration systems. Some studies have quantified the impact of wars by calculating years of life lost (YLL) due to premature deaths⁹⁻¹¹.

One metric used to assess the health of different populations is mortality rates, which are straightforward to measure due to their clear and unambiguous nature. The economist Collier (2004)¹² argued that wars are "development in reverse," causing immense human costs, including direct deaths from violence and indirect deaths from disease, malnutrition, and other war-related dangers. For instance, in Iraq, Afghanistan, Syria, Yemen, and Pakistan, approximately 929,000 people have been directly killed by war violence¹³. Millions more suffer from injuries, illness, displacement, and the destruction of infrastructure.

Sudan has a significant youth population, a demography that could propel the nation's future through proper education and employment. However, many of these young individuals have been killed in peaceful protests. To our knowledge, this study is a pioneer to quantify the loss of human lives and aims to:

1. Quantify the potential years of life lost in Khartoum State due to the mass demonstrations between October 2021 and October 2022.
2. Estimate the discounted monetary value of human lives lost due to the mass demonstrations.
3. Formulate policies to safeguard lives in future demonstrations.

METHODS

Data source

This study used data on 113 persons killed in mass demonstrations from October 25, 2021 to October 25, 2022, in Khartoum State. The data was categorized by the age of those who died, place of death, and type of injuries. One of those who died was excluded from the analysis because he was above the life expectancy. The data was collected by the Central Committee of Sudanese Doctors. While the data collection methods and potential biases in identifying the dead persons were not assessed, it is important to note that the violent events in Khartoum State were closely monitored by the local population. By the end of each day, the number of injured and dead individuals was publicly known, with demonstrators often going directly to hospitals and joining families for funerals and burials. To overcome the potential bias in estimating ages, the study grouped ages into categories, which helps in eliminating inaccuracies related to individual age reporting. This approach ensures a more reliable analysis of the demographic data of the dead. Other model variables, such as Gross Domestic Product (GDP) per capita and per capita health expenditure, were obtained from reliable sources and are presented in Table 1.

Human Capital Approach Model

The present study employed the human capital approach (HCA), proposed by Adam Smith in 1776, to estimate the monetary value of human life. Later, Weisbrod (1960)¹⁴ suggested measuring the loss of human capital resulting from premature death by calculating the deceased person's discounted future earnings, net of their consumption. This method involves estimating the future income that the deceased would have generated had they lived, and then discounting it to present value while subtracting the costs associated with their consumption, this approach attempts to quantify the economic impact of a premature death in terms of lost productivity and contributions to society. The HCA provides a monetary valuation of investments in education, health, and workforce development, aiding policymakers in prioritizing and allocating resources efficiently. It emphasizes long-term benefits, supports informed

decision-making, and promotes social equity by highlighting disparities in access to essential services. Nevertheless it has some limitations,^{15,16} which will be discussed later in the results.

The study used the total discounted value of human lives (TDVHL) as employed by previous studies^{8,17}, using the following equation:

$$TDVHL_{Sudan} = \sum_{i=1}^{i=n} DVHL_i \dots\dots\dots 1$$

DVHL_i denotes the discounted value of human lives lost for the age group_i during the mass demonstrations in Khartoum State from Oct. 2021 to Oct. 2022.

DVHL_i is calculated as:

$$DVHL_i = \sum_{t=1}^{t=n} \left(\frac{1}{(1+r)^t} \right) * (Y_1 - Y_2) * (Y_3 - Y_4) * (Y_5) \dots\dots\dots 2$$

The first term on the right-hand side of the equation is the discount factor; *r* is the discount rate, and *t* is the specific YLL. *Y*₁ is the GDP per capita in Sudan for 2021, *Y*₂ is the per capita health expenditure in Sudan for 2021, and the subtracted value is Sudan's net GDP per capita. *Y*₃ is the average life expectancy at birth in Sudan, and *Y*₄ is the average age at the onset of death for the *i*th age group. *Y*₅ is the number of deaths in age group *i*.

GDP per capita, per capita health expenditure, life expectancy, and the discount rate are the main model variables for calculating the discounted monetary value of years of life lost (YLL). **GDP per capita and health expenditure** reflect the economic resources and healthcare investment, which are crucial for estimating potential economic contributions lost due to premature death. **Life expectancy** provides a baseline for calculating the number of years lost, while the **discount rate** adjusts future costs and benefits to present value, affecting the robustness of results. The World Health Organization (WHO) recommends using per capita GDP net of current health expenditure in the valuation of YLL¹⁷. These variables together offer a comprehensive understanding of the economic impact of premature deaths, informing policy and investment decisions. **Table 1 illustrates the model data and data sources as follows:**

Table 1. Data used to estimate discounted and undiscounted YLL and their sources.

Y_1 : GDP per capita in Sudan	\$764.3 in 2021, World Bank data. Available online at: https://data.worldbank.org/indicator/NY.GDP.PCAP.CD?locations=SD
Y_2 : Current per capita health expenditure Net per capita is the per capita cost of health is subtracted from the per capita GDP of Sudan in 2021.	\$47 in 2019, World Data Atlas Sudan Health . Available online at: https://knoema.com/atlas/Sudan/Health-expenditure-per-capita
Y_3 : Average life expectancy in Sudan in 2022.	65.86 (U.N. projections)
Y_4 : Average of age group at the onset of death	For age group: $0 -14 = (0+14+1)/2 = 7.5$
Discount rate	3%
The discount factors (D.F.) using the formula: $\left(\frac{1}{(1+r)^t}\right)$	The discount factors for t_i are: $t=1, DF = \left(\frac{1}{(1+0.03)^1}\right) = 0.970873786,$ $t=2, DF = \left(\frac{1}{(1+0.03)^2}\right) = 0.942595909$ $t=3, DF = \left(\frac{1}{(1+0.03)^3}\right) = 0.915141659$ $t = n = 59.36, DF = \left(\frac{1}{(1+0.03)^{59.36}}\right) = 0.172975$

Assumptions

The study assumed the followings:

- Constant growth rate of GDP per capita based on 2021 figures.
- Homogeneity, according to the World Bank's open data, Sudan's Gini coefficient was 34.2 in 2014, indicating moderate income inequality. Additionally, protesters and those who demonstrate are almost from the same socioeconomic class.

Data analysis

Excel spreadsheet (2024) was used to estimate equations 1 and 2, followed by the steps presented below:

- The study excluded the dead whose age was above the average life expectancy at birth in Sudan in 2022. Only one dead person who was 70 years old and surpassed the life expectancy of 65.86 years, was excluded from the analysis because he had zero years lost.
- For each age group younger than the average life expectancy, the midpoint was calculated by adding the lower and upper bounds of the age group plus one and dividing by 2. Taking the age group 0 to 14 years as an example:
Midpoint = $(0 + 14 + 1) / 2 = 7.5$ [Other calculated values are shown in Table 2]

- For those younger than the average life expectancy, the study calculated undiscounted years of life lost (UYLL) per dead person by subtracting the midpoint of each age group from the average life expectancy at birth. Taking the age group 0 to 14 years as an example:

$$UYLL = 65.86 - 7.5 = 59 \text{ [Other calculated values are shown in Table 2]}$$

- The age specific UYLL was calculated by multiplying the per age group UYLL by the number of dead persons in the same age group. Taking the age group 0 to 14 years as an example:
 $59 * 6 = 354$ [Other calculated values are shown in Table 2]
- Sum the UYLL of each age group to obtain the TUYLL.

Discounting YLL

The HCA was used long ago to quantify the value of human life, and it was mainly based on maximizing the production of societies in the present and future¹⁸. The original version of HCA proposed that the value of the human life of individuals is determined by their future productions and can be measured by their expected future earnings. Later, Weisbord (1961)¹⁴ claimed that deceased persons lose not only their potential production but also their potential consumption; therefore, net consumption earnings was used in his

analysis. The estimates of YLL in this article used the average number of years a dead person would have lived if he had not been killed during mass demonstrations.

The discount rates are used to calculate the net present value of YLL. Though there was a debate around discounting health since health cannot be invested to produce future benefits like wealth, recent suggestions allow discounting future health benefits at a very low rate¹⁹.

Health economists agreed on 3% as an appropriate discount rate, which was used by a wide range of studies^{5,6,8,17}. However, discount rates vary according to economic conditions: lower rates are often used in developed countries to reflect their lower interest rates. In contrast, a discount rate of at least 5% is generally more appropriate for low- and lower-middle-income countries to account for higher economic and financial uncertainty. Discounting rates at 3% indicate that healthy years at the present time are valued 3% more than healthy years in the future²⁰. The study used the discounted YLL at 3% to calculate the total DYLL per a dead person in each age group by summing the discounted factors from year one to the last year of life.

Sudan is a lower-middle-income country, where the appropriate discount rate is 5% due to high economic uncertainty and fluctuations. However, the study used a lower discount rate of 3% to place a higher value on future benefits, which is advantageous for public health and social interventions aimed at long-term positive outcomes. Following previous research, the study initially employed a 3% rate and conducted sensitivity analysis using higher rates of 5% and 10%. The formula of the discounted factor is shown in table (1). Multiplying the DYLL per a dead person by the number of dead persons in the age group produced the total DYLL as shown in table 3. The discounted monetary value of human years of life lost per dead person is presented in Table 4.

Sensitivity analysis

Several discounting rates at 3%, 5%, and 10 % were used to consider how different rates influence the

analysis and the values of the percentage change in the present value of lost human lives. Based on that, the DVHL was computed using the global and Sub-Saharan African average life expectancies. This approach helps to ensure that the conclusions drawn are not overly dependent on specific assumptions and provides more comprehensive understanding of the model's behavior under different scenarios.

RESULTS

The total deaths of 112 persons during the mass demonstrations in Khartoum State from Oct 25, 2021, to Oct 25, 2022, resulted in a total of 4,713 undiscounted YLL, using the national average life expectancy estimated by the U.N. for 2022 (Table 2).

Most deaths belonged to the age group 20-24, followed by the age groups 15-19 and 25-29 (Figure 1). A total of 112 deaths was less than the average life expectancy in Sudan for the year 2022. The resulting 4,713 undiscounted years of life lost is equivalent to 2609.39 discounted at 3% human life lost (Tables 2 and 3).

The last column in Table (3) was multiplied by the net GDP in 2022 to obtain the total discounted money value of human life lost (TDVHLL). Column 1 in Table (4) depicts the TDVHLL due to shootings during the mass demonstrations in Khartoum State as \$1,871,743 and an average of \$136,816. About 6% of the TDVHLL was shared by the dead persons' aged (0-14), 26% by dead persons' aged 15-19, 38% by 20-24, 18% by 25-29, 3% by 30-34, 2% by 35-44, and 1% by 45-54. In summary, 82% of the TDVHLL was shared by dead persons aged 15-29. The average DVHLL per a dead person decreased with age. The average for the age group (14-19) was almost four times that of the last age group (55-59).

Sensitivity results

For sensitivity analysis, human life's total discounted money value was recalculated using the global and Sub-Saharan African average life expectancies. Substituting the Sub-Saharan average life expectancy reduced the TDVHL by \$105,821 (5.7%), whereas using the global average life expectancy increased the TDVHL by \$ 130,992 (7.0%), Table (5).

Table 2. Undiscounted years of life lost per a person who died during mass demonstrations in Khartoum State from Oct 25, 2021 to Oct 25, 2022.

Age group 1	Average life expectancy at birth in Sudan 2	Average age at the onset of death 3	Average years of life lost per dead person in the age group 4 = 2-3	Number of dead persons by age group 5	Total years of life lost per age group 6 = 4*5
0-14	65.86	7.5	59	6	354
15-19	65.86	17.5	49	27	1323
20-24	65.86	22.5	44	41	1804
25-29	65.86	27.5	39	21	819
30-34	65.86	32.5	34	4	136
35-39	65.86	37.5	29	4	116
40-44	65.86	42.5	24	3	72
45-49	65.86	47.5	19	2	38
50-54	65.86	52.5	14	3	42
55-59	65.86	57.5	9	1	9
60-64	65.86	62.5	4	0	0
65-69	65.86	67.5	0	0	0
70-74	65.86	72.5	0	1	0
75+	65.86	75.5	0	0	0
Total				113*	4,713

*One dead person's age was above the life expectancy and excluded from the analysis

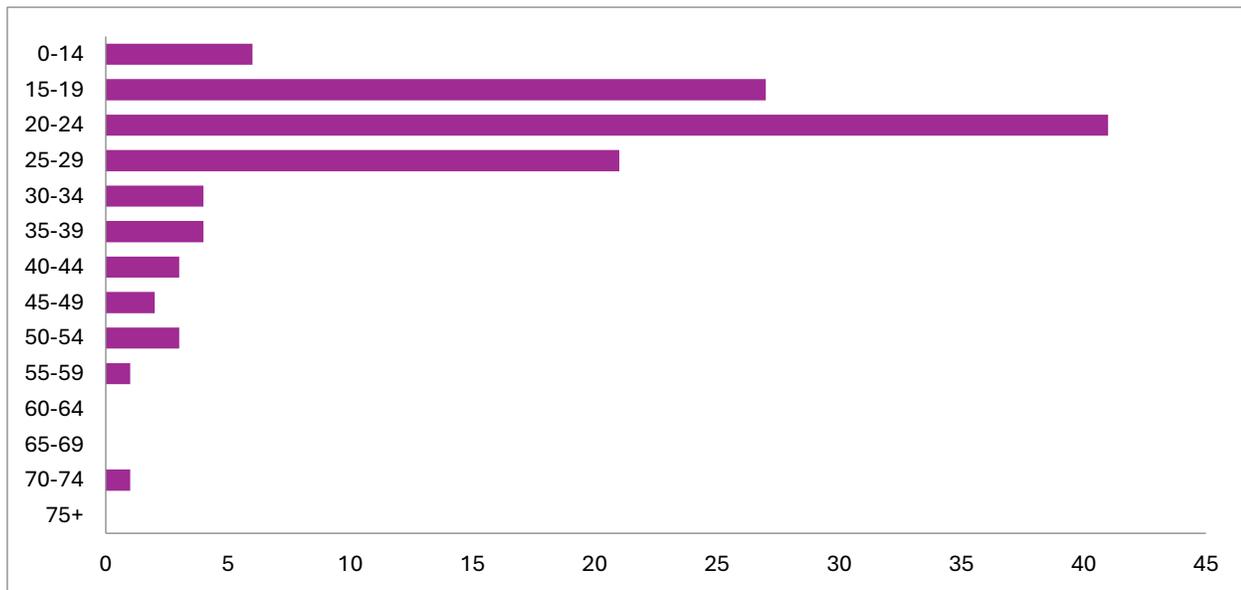


Figure 1. Distribution of dead persons by age group

Source: compiled by authors from data collected by the Central Committee of Sudanese Doctors from Oct 25, 2021, to Oct 25, 2022, in Khartoum State.

Table 3. Discounted years of life lost per a person who died during mass demonstrations in Khartoum State from Oct 25, 2021 to Oct 25, 2022, using the average life expectancy estimated by the U.N. and discount rate of 3%.

Age group	Discounted years of life lost per age group.	Number of dead persons by age group	Total discounted years of life lost per age group
0-14	27.50583058	6	165.03
15-19	25.50165693	27	688.54
20-24	24.25427392	41	994.43
25-29	22.80821513	21	478.97
30-34	21.14281802	4	84.57
35-39	19.18845459	4	76.75
40-44	16.93554212	3	50.81
45-49	14.32379911	2	28.65
50-54	11.29607314	3	33.89
55-59	7.786108922	1	7.79
60-64	3.717098403	0	0.00
Total		112	2609.43

DISCUSSION

Premature deaths have profound impacts on various levels: individual, household, and national. Individually, they cut short lives, depriving people of joys, the ability to care for their families, and achieving personal and economic milestones. Nationally, these deaths halt contributions to national production⁸, spending,

investments, and tax payments, thereby reducing GDP. Beyond economic impacts, society loses intangible contributions such as the joy children bring to parents, love to family and friends, companionship, shared knowledge, and social values. Premature death extinguishes a person's potential for personal growth, leisure, societal contributions, enjoyment of life, love, religious practice, and fulfilling societal roles.

Premature deaths are more prominent in less developed countries, caused either by controllable diseases or due to armed conflicts and wars. Sudan, as a developing country, experiences a disproportionate number of premature deaths mainly due to ongoing political instability and conflicts. Millions of people were killed in the South-North civil wars, and in Darfur, Blue Nile, and Kordofan. According to Sky News, the most recent conflict in April 2023 resulted in over 10

million deaths, with the majority being youth and children. During the Syrian war between 2011 and 2016, approximately 110,453 civilians were killed. The proportion of children among those who were killed increased from 8.9% in 2011 to 19% in 2013 and 23.3% in (2016)¹⁰. Children were also used as soldiers, which is a violation of human rights. Countries lost the youth who were supposed to drive the future of the nation.

Conflicts are serious public health problems, albeit few studies have addressed the economic consequences of wars and conflicts. As estimated by WHO, about 0.70% of the global disease burden in the year 2000 was due to conflict, including years of life lost and years of life lived with disability⁴. According to the United Nations (2016), "people's economic well-being is determined not only by current income and consumption but also by the assets they own, such as housing property, financial assets, and, importantly, human capital²¹." Healy and Côté (2001)²² define human capital as "the knowledge, skills, competencies, and attributes embodied in individuals that facilitate the creation of personal, social, and economic well-being." In business economics, human capital is regarded as a factor of production. From a managerial perspective, human capital is viewed as a business resource or asset that contributes to the company's market value.²³.

Table 4. Discounted money value of human life lost due to mass demonstrations in Khartoum State from Oct 25, 2021 to Oct 25, 2022, using the average life expectancy estimated by the U.N. and discount rate of 3%.

Age group	Discounted money value of human years of life lost per dead person in dollars (\$)	Average discounted money value per human life lost in an age group	Percent of the total discounted money value of human years of life lost per dead person in dollars (\$)
0-14	118,376	19,729	6.32
15-19	493,890	18,292	26.39
20-24	713,305	17,398	38.11
25-29	343,565	16,360	18.36
30-34	60,663	15,158	3.24
35-39	55,053	13,763	2.94
40-44	36,446	12,149	1.95
45-49	20,551	10,275	1.10
50-54	24,309	8,103	1.30
55-59	5,588	5,588	0.30
60-64	0	0	0
Total	1,871,745	136,816	100

Table 5. Discounted money value of human life lost due to mass demonstrations in Khartoum State, at 3%, using the national life expectancy, average global life expectancy, and average Sub-Saharan life expectancy in 2020.

Age group	The discounted money value of human years of life lost at 3% per dead person in dollars (\$), using the life expectancy of Sudan, 2020	The discounted money value of human years of life lost at 3% per dead person in dollars (\$), using the life expectancy of Sub-Saharan Africa, 2020	Discounted money value of human years of life lost at 3% per dead person in dollars (\$), using Global average life expectancy, 2020
0-14	118,380	115279	122456
15-19	493,893	475069	518543
20-24	713,301	680112	756694
25-29	343,567	318481	369333
30-34	60,663	56238	66321
35-39	55,056	49962	61651
40-44	36,444	32015	42178
45-49	20,549	17126	24981
50-54	24,308	18356	32015
55-59	5,585	3285	8563
60-64	0	0	0
Total	1,871,743	1,765,922	2,002,735

Table 6. Discounted money value of human life lost due to mass demonstrations in Khartoum State, at 3%, 5%, and 10% per dead person in 2022 in dollars (\$)

Age group	Discounted money value of human years of life lost at 3% per dead person in dollars (\$)	Discounted money value of human years of life lost at 5% per dead person in dollars (\$)	Discounted money value of human years of life lost at 10% per dead person in dollars (\$)
0-14	118,376	81237.47	42882.52
15-19	493,890	351875.45	191856.2
20-24	713,305	519449.8	289654.8
25-29	343,565	256332.79	146972
30-34	60,663	46460.68	27568.92
35-39	55,053	43442.768	26883.27
40-44	36,446	29693.297	19334.27
45-49	20,551	17337.601	12000.31
50-54	24,309	21300.885	15852.37
55-59	5,588	5098.4405	4130.948
60-64	0	0	0
Total	1,871,745	1,372,229	777,136

Based on the aforementioned, knowledge, skills, and competence, along with other characteristics inherent in individuals, promote human capital and lead to social and economic development. Youth are the carriers of knowledge, skills, and innovations in all aspects of life, and they shoulder all development programs²⁴. Accordingly, countries should focus on educating youth, taking care of their health, striving to employ them, and then reap the demographic dividends. Contrary to what happened in East Asia in the last four decades, the Arab countries and the Middle East failed to benefit from the youth bulge in their countries; instead, they witnessed the Arab Spring. Sudan, as one of the Arab countries, witnessed the Arab Spring in 2019, with protests and the uprising ending in the overthrow of the Ingaz government. Political instability and uprisings continue, culminating in the war of today. Though death and injury among demonstrating youth were in full view of everyone, official data was not available. The registration system avoids registering deaths during conflicts as it is highly politicized. However, the Central Committee of Sudanese Doctors registered 113 deaths one year after the military coup in October 2021, with data segregated by age, place of death, and injuries.

This study aims to raise awareness among policymakers about safeguarding civilian lives, with a specific focus on youth. While acknowledging the ethical considerations, we opted to continue the research, recognizing its possible influence on decision-makers. Despite the potential bias in the data collected by the Central Committee of Sudanese Doctors, the authors utilized it because the events were closely monitored by demonstrators who attended funerals, burials of the dead persons, and visited their families. Age misreporting can be addressed through age grouping. The authors were keenly aware by the ethical dimension of dealing with data on dead persons. The study obtained just the age of the dead and grouped them in five-year age groups.

In line with previous studies, this one adopted HCA in estimating the discounted monetary values of human lives lost due to mass demonstrations. HCA helps in projecting and discounting future earnings, considering consumption costs, and providing a clear measure of the economic impact of premature deaths. This informs policy decisions and underscores the importance of investments in health and safety.

Discounting health is controversial because it implies that future health benefits are less valuable than present ones. This raises ethical concerns, issues of intergenerational equity, and potential biases against long-term health policies. The choice of discount rate is subjective and significantly impacts health economic evaluations. The study initially used a 3% discount rate but also re-estimated the model using 5% and 10%, as well as different life expectancies (African average and global). A constant GDP growth rate is assumed, because GDP fluctuation imposes difficulties in estimating future benefits. Additionally, we assumed homogeneity and socioeconomic equality.

The findings show that 84% of the dead persons were below 30 years, and the TDVHLL is \$1,871,745, equivalent to 0.005% of Sudan's GDP in 2021. The average discounted value of human life lost (HLL) due to killing peaceful protestors in mass demonstrations in Khartoum (\$136,816) is 179 times the per capita GDP in Sudan in 2021 and 1.6 times the average discounted value of HLL due to COVID-19 in Africa²⁵. However, it is lower than the average discounted value of HLL due to COVID-19 in France⁸ and Mauritius¹⁷ by 60% and 56%, respectively. This discrepancy is due to lower life expectancy and GDP per capita in Sudan compared to France and Mauritius. About 82% of the TDVHLL was shared by dead persons aged 15-29. The average DVHLL per dead person decreases with age, with the average for the age group (14-19) being almost four times that of the last age group (55-59). The findings highlight the significant costs of arbitrarily shooting peaceful protestors and suggest that the country is losing its future labor force. Low-income countries, unless they recognize the importance of youth as an economic asset, will remain in a vicious cycle. Poverty is a risk factor for conflicts,¹² and conflicts, in turn, lead to poverty.

Economic models never estimate the grief that premature deaths leave behind. These models, including HCA, have limitations. HCA reduces the value of human life to purely economic terms, overlooking intrinsic and non-economic aspects¹⁵. This approach can exacerbate social and economic inequalities by valuing lives differently based on economic output¹⁶, raising ethical concerns about placing a monetary value on life. This can lead to morally questionable

decisions, such as underinvesting in the health and safety of lower-income individuals. Additionally, HCA's emphasis on future earnings may undervalue the long-term contributions of the young or those not yet in the workforce. It assumes constant future earnings, ignoring changes due to promotions, economic fluctuations, unemployment, or non-market activities¹⁴. The choice of discount rate can greatly impact results, and uncertainties in health and lifespan can introduce inaccuracies²⁶. By providing a tangible measure of the economic impact of premature deaths, the study emphasizes the urgency of implementing protective measures and policies to prevent further loss of young lives in future demonstrations. This can guide targeted interventions, support humanitarian aid programs, and advocate for stronger legal frameworks to protect civilians and uphold human rights and the rule of law.

A primary limitation of this study is the scarcity and reliability of the data on the dead segregated by age and sex. The data from the Central Committee of Sudanese Doctors may not fully capture all deaths resulting from the conflict, given the incomplete and politicized nature of civil registration systems during such times. Furthermore, the calculation of the total discounted monetary value of human life lost (TDVHLL) relies on specific economic assumptions, including discount rates and projected earnings potential, which may not precisely reflect Sudan's current economic realities. Additionally, from an emotional perspective, human life is difficult to gauge by any means.

CONCLUSION

This study fills a crucial knowledge gap by providing a quantitative analysis of the mortality and economic impact of conflicts in Sudan, where data scarcity in civil registration systems has always limited such research. By estimating the TDVHLL due to shootings during the Khartoum State mass demonstrations at \$1,871,743, with an average of \$136,816 per individual, the study highlights the significant economic burden of premature deaths. Approximately 82% of the TDVHLL was attributed to persons aged 15-29, with the average value for the 14-19 age group nearly four times higher than that of the 55-59 age group. These findings underscore the high cost of premature deaths in Sudan, particularly among the youth, who represent the

nation's potential for future economic and social development.

The significance of this contribution lies in its potential to inform policy formulation and risk assessment. Economic valuations of human life lost due to conflict provide valuable insights for policymakers, emphasizing the importance of protecting young lives and investing in the stability and development of the nation. However, these valuations must be contextualized within a broader ethical framework, aiming to foster a society where the value of human life is upheld and protected. Moving forward, it is essential to integrate both quantitative and qualitative factors in decision-making processes to create comprehensive policies that address the root causes of conflict and promote long-term peace and development in Sudan.

The study also emphasizes the following policy recommendations:

1. Banning police officers from using guns against demonstrators: This could help reduce the risk of mass shooting deaths by limiting their access to firearms when monitoring demonstrations.
2. Focusing more on peaceful conflict resolution through community participation: Engaging communities in dialogue and mediation can help address underlying issues and prevent violent conflicts.
3. Supporting research on robust data collection and analysis: This is crucial for evidence-based policymaking, enabling better understanding and management of conflict-related issues and the effectiveness of interventions.

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CONFLICT OF INTEREST

The authors declare that they have no conflict of interest.

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AUTHORS' CONTRIBUTIONS

Authors worked as a team, we all designed the study, the first and the third authors analyzed the data, the second author collected and wrote the literature review. The first author drafted the paper. All authors reviewed, edited and approved the final.

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