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The pecuniary value of human life losses associated with COVID-19 in Brazil

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Abstract:
Background: Coronavirus Disease (COVID-19) pandemic is causing havoc to human life and economy in Brazil. This study estimated the discounted pecuniary value of human life (TPVHL) losses associated with COVID-19 in Brazil.
Materials and Methods: The human capital approach appraised the TPVHL of the 36,044 human lives lost to COVID-19 in Brazil by 7 June 2020. The model was estimated five times. First, with a 3% discount rate and Brazil's life expectancy at birth of 75.1 years. Second, using a 5% discount rate, holding Brazil's life expectancy constant at 75.1 years. Third, utilising a 10% discount rate, maintaining Brazil's life expectancy at 75.1 years. Fourth, with the global average life expectancy at birth of 72 years, holding discount rate constant at 3%. Fifth, applying the world highest average life expectancy at birth of 87.1 years, keeping the 3% discount rate.
Results: The 36,044 human lives lost had a TPVHL of Int$3,591,028,164, and an average value of Int$99,629 per human life lost. Use of 5% and 10% discount rates resulted in decrements in the TPVHL of Int$534,043,924 (15%) and Int$1,383,376,395 (39%), respectively. Application of the average global life expectancy of 72 years diminished TPVHL by Int$699,777,517 (19.5%). Whereas, use of the world's highest life expectancy of 87.1 years increased TPVHL by Int3,692,888,818 (103%).
Conclusion: The average of total pecuniary value per human life lost from COVID-19 was 5.85-fold the GDP per capita for Brazil in 2020.
Key Word: Brazil; Coronavirus; COVID-19; Value of human life; Gross domestic product.

I. INTRODUCTION

Brazil has a population of 212,446,884 persons [1], which is the largest in the Latin America and the Caribbean, and the second largest in the World Health Organization (WHO) Region of the Americas. The country has a gross domestic product (GDP) of Int$3,596.841 billion, a GDP per capita of Int$17,016.318 [2], and a human development index (HDI) of 0.761 [3]. According to IMF [4], Brazil's real GDP growth is projected to decrease by -5.3 % due to the Coronavirus Disease (COVID-19) pandemic in 2020.

Globally, by 7th June 2020, there was a total of 6,981,427 cases of coronavirus disease (COVID-19), which included 402,237 deaths, 3,413,283 recovered cases, and 3,165,907 active cases [1]. As of 7th June 2020, Brazil had a total of 676,494 COVID-19 cases, which included 36,044 deaths, 302,084 recovered cases, and 338,366 active cases. Density-wise, there were 3,184 total cases per million population, and 170 deaths per million population in Brazil [1].

The rapidly growing burden of COVID-19 in Brazil may be associated with human development inequalities and poverty, and gaps in the coverage of essential health services, safely managed water services, and safely managed sanitation services, and International Health Regulation (IHR) capacity.

Brazil Brazil has an inequality-adjusted HDI of 0.574 and a Gini coefficient of 53.3 [3]. About 1,912,022 (0.9%) persons live in severe multidimensional poverty, and 13,171,707 (6.2%) are vulnerable to multidimensional poverty. Approximately 56,298,424 (26.5%) live below the national income poverty line, and 10,197,450 (4.8%) live below the international income poverty line of Int$1.90 a day. The people vulnerable to multidimensional poverty and those living below income poverty line may not afford the COVID-19 preventive and control interventions recommended by the WHO [5], and thus, the Brazilian Government will need to assure their access.

Brazil has Universal Health Coverage (UHC) index of 79% [6], implying that about 21% of the population in need do not receive reproductive, maternal, new-born and child health; infectious diseases; and non-communicable diseases services; and do not have access to hospitals and essential medicines [7]. 25.6% of households spend 10%, and 3.5% of households spend at least 25% of their total income on health care, exposing them to catastrophic expenditure and potential impoverishment [8].

Approximately, 98% population use improved drinking water sources [9]; and 49% of the population use safely-managed sanitation services [6]. Thus, 4,248,938 (2%) and 108,347,911 (51%) persons do not have access to safely managed drinking water and sanitation services, respectively. Such people may have challenges practising handwashing to protect themselves from COVID-19 infection. Also, physical distancing is a challenge for 22.3% of the urban population residing in slums [10].

The average of 13 IHR core capacities score was 87 [6], signifying an average gap of 13. Out of the 13 core capacities, legislation and financing, coordination and national focal point functions, laboratory, surveillance, human resources, zoonotic events, chemical events, and radiation emergencies had self-assessed scores of 100 [11], meaning they were optimally performing in 2019. However, there were gaps of 60 in health service provision, 40 in points of entry, 27 in national health emergency framework, 20 in risk communication, and 20 in food safety.

The coverage gaps in UHC, IHR, and social determinants of health (water, sanitation, poverty, inequalities) imply that the Brazilian Government needs to invest more to alleviate the gaps. Evidence on the value of human life, jointly with human rights reasons, can be used to build a case for investing more in health development to improve preparedness and response to pandemics. There is a scarcity of such evidence in Brazil, especially as it relates to human life lost due to COVID-19. This study estimated the discounted pecuniary value of human life (TPVHL) losses associated with COVID-19 in Brazil.

II. MATERIAL AND METHODS

Study Location: This health economics study included all the 36,044 patients who died of COVID-19 in Brazil between 25 February 2020 (when the first case was reported in the country) and 7 June 2020.
Study Design: This is a cross-sectional human capital valuation of human life study.
Sample size: The study included entire population of the 36,044 patients who died of COVID-19 by 7 June 2020. Thus, no sampling was required.

An analytical framework for estimating the pecuniary value of human life

The total pecuniary value of the 36,044 human lives lost from COVID-19 as of 7 June 2020 in Brazil was estimated using the human capital approach. According to Rice [12], "*In the human capital approach, a person is seen as producing a stream of output that is valued at market earnings and the value of life is the discounted future earnings stream*" (p.177). Premature death results in potentially productive years of life lost (YLL), which equals Brazil's life expectancy at birth minus the age of onset of death. The YLL are valued using GDP per capita net of the current health expenditure per capita. We used the net GDP per capita because as explained by Weisbrod [13], World Health Organization (WHO) [14], and Chisholm *et al.* [15], consumption of health goods and services do no yield utility.

This study replicates the methodology applied in the valuation of human life losses associated with COVID-19 in China [16], USA [17], and Iran [18]. The COVID-19 deaths in Brazil were disaggregated into nine age groups, i.e. 1 = 0-9 years, 2 = 10-19 years, 3 = 20-29 years, 4 = 30-39 years, 5 = 40-49 years, 6 = 50-59 years, 7 = 60-69 years, 8 = 70-79 years, and 9 = 80 years and older. The total pecuniary value of human lives lost due to COVID-19 in Brazil ($TPVHL_{BRAZIL}$) is a sum of the pecuniary values of human lives lost due to COVID-19 in the nine age groups $(PVHL_{j=1,..,9})$ [16,17,18]. Algebraically:

$$TPVHL_{BRAZIL} = \sum_{j=1}^{j=9} PVHL_j \dots\dots\dots\dots\dots\dots (1)$$

The discounted $PVHL_{j=1,..,9}$ for each of the nine age groups were estimated using the following formula:

$$PVHL_{j=1,..,9} = \sum_{t=1}^{t=k} Z_1 \times (Z_2 - Z_3) \times (Z_4 - Z_5) \times (Z_6 \times Z_7) \dots\dots\dots\dots (2)$$

Where: $\sum_{t=1}^{t=k}$ is a summation from t=1 (i.e. first YLL) to t=k (i.e. last YLL); Z_1 is the discount factor, i.e. $1/(1+r)^k$; r is the discount rate of 3% in this study [16,17,18]; Z_2 is the Brazil life expectancy at birth [6]; Z_3 is the age of onset of death in group j; Z_4 is the GDP per capita [2]; Z_5 is the current health expenditure per capita [19]; Z_6 is the number of deaths from COVID-19 as of 7 June 2020 in Brazil [1]; Z_7 is the proportion of COVID-19 deaths belonging to j^{th} age group [20]. The base year for the calculations was 2020.

Data and Data Sources

The data used in the analysis and sources were:

a) Discount rates of 3%, 5% and 10% from similar studies in China [16], the USA [17], and Iran [18].
b) Brazil average life expectancy at birth (AVLE) of 75.1 years; the global AVLE of 72 years; and the Japanese Females AVLE (world highest) of 87.1 years were from the WHO World Health Statistics 2020 report [6].
c) Age of death onset among 0-9 years = (0+9)/2=4.5 years; 10-19 years = (10+19)/2 = 14.5 years; 20-29 years = (20+29)/2 = 24.5 years; 30-39 years = (30+39)/2 = 34.5 years; 40-49 years = (40+49)/2 = 44.5 years; 50-59 years = (50+59)/2 = 54.5; 60-69 years = (60+69)/2 = 64.5; and 70-79 years = (70+79)/2 = 74.5 years.
d) Brazil GDP per person of Int$17,016.318 was from the IMF World Economic Outlook Database [2].
e) Brazil current health expenditure per person of Int$1,472.231 was from the WHO Global Health Expenditure Database [19].
f) The 36,044 deaths from COVID-19 as of 7 June 2020 in Brazil was from Worldometer live database [1].
g) The proportion of COVID-19 deaths by age group (0-9 years = 0; 10-19 years=0.000977517; 20-29 years = 0.00684262; 30-39 years = 0.017595308; 40-49 years = 0.03714565; 50-59 years = 0.127077224; 60-69 years = 0.302052786; 70-79 years = 0.304985337; 80 years and older = 0.203323558) were from Verity *et al.* [20].

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Statistical analysis

Equations 1 and 2 were estimated using Excel Software (Microsoft, New York).

III. RESULT

Findings from analysis assuming Brazil's average life expectancy of 75.1 years and 3% discount rate

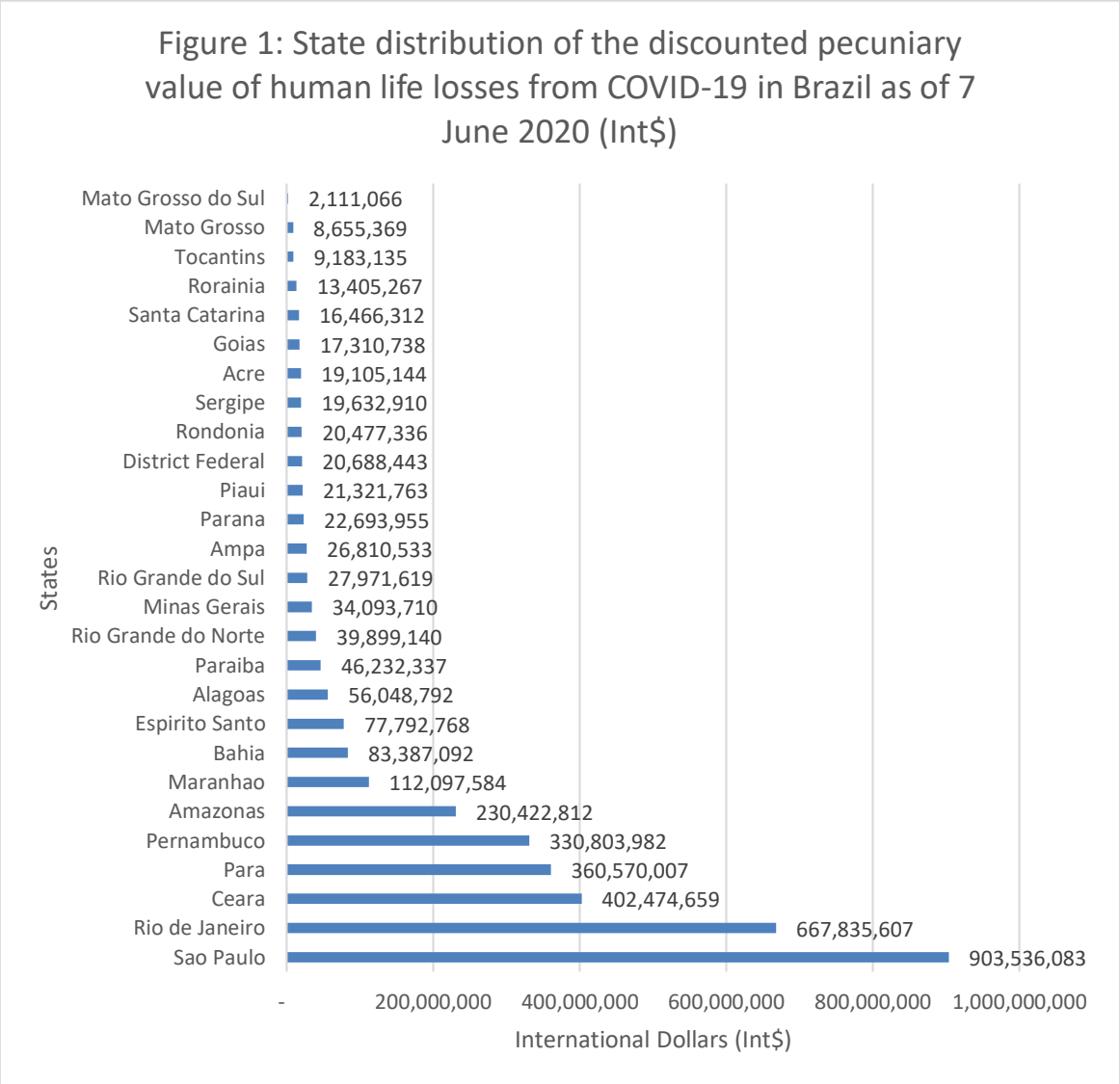
As shown in Table 1, the 36,044 human life losses associated with COVID-19 had a total pecuniary value of Int$3,591,028,164; of which, 0% accrued to 0-9-year-olds, 0.4% to 10-19-year-olds, 2.8% to 20-29-year-olds, 6.4% to 30-39-year-olds, 11.6% to 40-49-year-olds, 30.6% to 50-59-year-olds, 43.6% to 60-69-year-olds, 4.6% to 70-79-year-olds, and 0% to 80 years and above. About 92.2% of the TPVHL accrued to persons aged between 30 and 69 years. The average of total pecuniary value per human life lost was Int$99,629. The average pecuniary value per human life lost in the age group 10-19 was almost 29-fold that of 70-79-year-olds.

Table 1: The total and average discounted pecuniary value of human life losses associated with COVID-19 in Brazil – assuming the national average life expectancy and a 3% discount rate (in 2020 Int$)

Age group in years	Pecuniary value of human lives lost at 3% discount rate (Int$)	Average pecuniary value per human life lost in an age group (Int$)
0-9	0	0
10-19	15,247,453	432,753
20-29	99,489,788	403,388
30-39	230,802,765	363,924
40-49	416,241,582	310,888
50-59	1,097,514,150	239,612
60-69	1,565,834,889	143,824
70-79	165,897,536	15,091
80 & over	0	0
TOTAL	**3,591,028,164**	**99,629**

Distribution of the TPVHL by States in Brazil

Figure 1 shows the share of TPVHL borne by the 27 States in Brazil.



The TPVHL accruing to States varied widely from a minimum of Int$2,111,066 to a maximum of Int$903,536,083. Fourteen States had a TPVHL of less than Int$30,000,000; four States had Int$30,000,000 - 59,999,999; two States had Int$60,000,000 - 89,999,999; and the remaining seven States had Int$90 million and above. About Int$2,665,220,339 (74.2%) of the TPVHL accrued to only five States, namely São Paulo, Rio de Janeiro, Ceará, Pára, and Pernambuco.

Sensitivity of TPVHL to changes in the discount rate

Reanalysis of the economic model with discount rates of 5% and 10%, while holding the national life expectancy constant, yielded the TPVHL values shown in Table 2.

Table 2: The discounted pecuniary value of human life losses associated with COVID-19 in Brazil – assuming 5% and 10% discount rates (in 2020 Int$)

Age bracket in years	Pecuniary value of human life lost at 5% discount rate (Int$)	Pecuniary value of human life lost at 10% discount rate (Int$)
0-9	0	0
10-19	10,395,014	5,460,394
20-29	70,306,537	38,040,330

30-39	170,490,336	96,601,285
40-49	324,511,853	197,273,745
50-59	912,836,489	615,767,078
60-69	1,405,706,428	1,099,168,518
70-79	162,737,583	155,340,420
80 & above	-	-
TOTAL	3,056,984,240	2,207,651,769
Average pecuniary per human life lost	**84,813**	**61,249**

Subsequent reanalysis of the model with 5% and 10% discount rates, while holding the national life expectancy constant, resulted in decrements in the TPVHL of Int$534,043,924 (15%) and Int$1,383,376,395 (39%), respectively. The corresponding average pecuniary values per human life diminished by Int$14,816 and Int$38,380.

The Sensitivity of TPVHL to changes in average life expectancy

Re-estimation of the economic model with the average global life expectancy of 72 years and the world highest average life expectancy, holding the discount rate constant at 3%, produced the TPVHL values depicted in Table 3.

Table 3: The discounted pecuniary value of human life losses associated with COVID-19 in Brazil – assuming average global and world's highest life expectancies (in 2020 Int$)

Age bracket in years	**Pecuniary value of human life lost at 3% discount rate and average global life expectancy of 72 years (Int$)**	**Pecuniary value of human life lost at 3% discount rate and the world's highest life expectancy of 87.1 years (Int$)**
0-9	0	0
10-19	14,968,496	16,145,812
20-29	96,865,527	107,941,019
30-39	221,733,881	260,008,401
40-49	390,511,738	499,102,551
50-59	979,218,397	1,478,476,460
60-69	1,187,952,608	2,782,775,503
70-79	-	1,817,242,274
80 & above	0	322,224,963
TOTAL	**2,891,250,647**	**7,283,916,982**
Average pecuniary value per human life lost	**80,214**	**202,084**

Application of the average global life expectancy, which is three years lower than Brazil's life expectancy, diminished the TPVHL by Int$699,777,517 (19.5%). Whereas, recalculation of the same model with the world's highest life expectancy, increased the TPVHL by Int$3,692,888,818 (103%).

IV. DISCUSSION

Key findings and implications

- The 36,044 human lives lost had a total pecuniary value of Int$3,591,028,164.
- The average of total pecuniary value per human life lost was Int$99,629.
- Use of 5% and 10% discount rates resulted in decrements in the TPVHL of Int$534,043,924 (15%) and Int$1,383,376,395 (39%), respectively.
- Application of the average global life expectancy of 72 years diminished TPVHL by Int$699,777,517 (19.5%).
- Application of the world's highest life expectancy of 87.1 years increased TPVHL by Int3,692,888,818 (103%).

Comparison with results on other countries: A rapid search of the internet revealed only three studies that used the human capital approach to value human life losses associated with COVID-19. Brazil average value per human life loss of Int$99,629 was 3.6-fold lower than China's Int$356,203 [16]; 2.9-fold that of the USA of Int$292,889 [17]; and almost comparable with that of Iran of Int$103,090 [18].

Implications of the findings: Economic evidence in combination human rights arguments can be used to build a case for investing more resources to alleviate coverage gaps in UHC, IHR, and social determinants of health to improve preparedness and response to public health emergencies, such as the COVID-19 pandemic.

Further economic studies are needed to: (a). Estimate the monetary value of deaths prevented by various COVID-19 interventions [21]. (b). An economic evaluation of alternative preventive, diagnostic, isolation, quarantine, and treatment options for COVID-19 [22,23].

Limitations of the study

First, the reported number of COVID-19 infections in Brazil was after 999,836 tests, i.e. 4,706 tests per a million population [1]. The 4,706 tests per million population in Brazil was far much lower than 62,919 in the USA and 84,896 in Russia. Given the low level of testing among the 212,446,884 population in Brazil, the actual burden of COVID-19 is likely to be far much higher than currently reported, implying that even the estimated TPVHL is likely to be an underestimate.

Second, human life losses occurring above the Brazil average life expectancy of 75.1 years were valued at zero, which discriminates against older persons. Although, reanalysis of the economic model with the world's highest life expectancy of 87.1 years, led to a 103% increase in the TPVHL.

Third, in the current study, the GDP per capita was used in the valuation of human life. However, this economic activity indicator ignores the inequalities in human development and the damaging effects of industrial production processes on the environment [24].

Fourth, the cost of health system inputs used in prevention, diagnosis, isolation, quarantine, treatment of COVID cases was beyond the scope of the current study [16]. Also, the cost of post-mortem and burial was not taken into account [17,18].

V. CONCLUSION

The average of total pecuniary value per human life lost from COVID-19 was 5.85-fold the GDP per capita for Brazil in 2020. The pandemic has so far had a significant negative impact on public health and the economy of Brazil. It calls for increased investments to eliminate the persisting gaps in UHC, IHR, water and sanitation to improve Brazil's response to the ongoing COVID-19 pandemic, and other public health emergencies that are likely to occur in future.

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Ethical approval: Not required. The study relied completely on analysis of secondary data that is available for public use in the IMF, WHO, and Worldometer databases.

Author contribution: JMK, RNDKM, LHKN, and NGM contributed equally in the design of the study, literature review, development of the human capital model in Excel Software, retrieval of data from international databases, and writing of the manuscript.

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REFERENCES

[1]. Worldometer. COVID-19 Coronavirus Pandemic (Last updated: June 07, 2020, 04:42 GMT). [Online]. Retrieved from:https://www.worldometers.info/coronavirus/. Accessed 7 June 2020.
[2]. International Monetary Fund (IMF). World Economic Outlook Database. [Online].https://www.imf.org/external/pubs/ft/weo/2019/02/weodata/index.aspx. Accessed 19 May 2020.
[3]. United Nations Development Programme (UNDP). Human Development Report 2019. Beyond income, beyond averages, beyond today: Inequalities in human development in the 21st century Empowered lives. New York: UNDP; 2019.
[4]. IMF. G-20 surveillance note. COVID-19—Impact and Policy Considerations. G-20 Finance Ministers and Central Bank Governors' Meetings, April 15, 2020 virtual meeting. Washington, D.C.: IMF; 2020.
[5]. World Health Organization (WHO). COVID-19 strategy update. Geneva: WHO; 2020a.
[6]. WHO. World Health Statistics 2020: Monitoring health for the SDGs. Geneva: WHO; 2020b.
[7]. WHO and The World Bank. Tracking universal health coverage: 2017 global monitoring report. Geneva/Washington DC: WHO and The World Bank; 2017.
[8]. WHO and The World Bank. Global Monitoring Report on Financial Protection in Health 2019. Geneva/Washington DC; 2019.
[9]. WHO. World health statistics 2017: monitoring health for the SDGs, Sustainable Development Goals. Geneva: World Health Organization; 2017.
[10]. World Bank. World Development Indicators: Global goals: promoting sustainability. [Online]. Retrieved from:http://wdi.worldbank.org/table/WV.3. Accessed 1 June 2020.
[11]. WHO. The Global Health Observatory. Health emergencies. [Online]. Retrieved from:https://www.who.int/data/gho/data/major-themes/health-emergencies; 2020. Accessed 7 June 2020.
[12]. Rice DP. Cost of illness studies: what is good about them? *Injury Prevention.* 2000; **6**(3):177–179. http://doi.org/10.1136/ip.6.3.177.
[13]. Weisbrod BA. The valuation of human capital. *Journal of Political Economy*.1961; **69**(5):425-436. https://doi.org/10.1086/258535.
[14]. WHO. WHO guide to identifying the economic consequences of disease and injury. Geneva: WHO; 2009.
[15]. Chisholm D, Stanciole AE, Edejer TTT, Evans DB. Economic impact of disease and injury: counting what matters. *British Medical Journal*.2010;**340**:c924. https://doi.org/10.1136/bmj.c924.
[16]. Kirigia JM, Muthuri RNDK. The fiscal value of human lives lost from coronavirus disease (COVID-19) in China. *BMC Research Notes* 2020; **13**:198. https://doi.org/10.1186/s13104-020-05044-y.
[17]. Kirigia JM, Muthuri RNDK. Discounted monetary value of human lives lost due to COVID-19 in the USA as of 3 May 2020. *IOSR Journal of Dental and Medical Sciences.* 2020; **19**(5):51-54. DOI: 10.9790/0853-1905105154
[18]. Kirigia JM, Muthuri RNDK, Muthuri NG. The net present value of human lives lost due to coronavirus disease (COVID-19) in the Islamic Republic of Iran. *Research Square*. 2020. http://doi.org/10.21203/rs.3.rs-24711/v1 Accessed 11 June 2020.
[19]. WHO. Global Health Expenditure Database. [Online]. Retrieved from: https://apps.who.int/nha/database/Select/en.Accessed on 7 June 2020.
[20]. Verity R, Okell LC, Dorigatti I, Winskill P, Whittaker C, Imai N, *et al*. Estimates of the severity of coronavirus disease 2019: a model-based analysis. *Lancet Infectious Diseases*. 2020. https://doi.org/10.1016/ S1473-3099(20)30243-7.
[21]. Dolan P, Pinar J. Estimating the monetary value of the deaths prevented from the UK Covid-19 lockdown when it was decided upon -- and the value of "flattening the curve". London: London School of Economics and Political Science; 2020. URL: http://eprints.lse.ac.uk/104355/
[22]. Drummond MF, Sculpher MJ, Torrance GW, O'Brien BJ, Stoddart GL. Methods for the economic evaluation of health care programmes. Oxford: Oxford University Press; 2007.
[23]. Kirigia JM. Economic evaluation of public health problems in sub-Saharan Africa. Nairobi: University of Nairobi Press; 2009.
[24]. Stiglitz J, Sen A, Fitoussi J-P. Mis-measuring our lives: Why GDP doesn't add up: The report. New York: New Press; 2010.

Joses Muthuri Kirigia, et. al. "The pecuniary value of human life losses associated with COVID-19 in Brazil." *IOSR Journal of Pharmacy (IOSRPHR)*, 10(8), 2020, pp. 45-51.