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The present value of human life losses from Coronavirus Disease (COVID-19) in India

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Abstract:
Background*: The coronavirus disease (COVID-19) has had an adverse effect on both health and socioeconomic development of India. The specific study objective was to estimate the total present value of human life losses (TPV) associated with COVID-19 in India as of 3 October 2020.*
Materials and Methods*: The standard human capital approach model (HCAM) was applied to value monetarily, at a 3% discount rate, the 100,875 human lives lost in India from COVID-19 as of 3 October 2020. In the one-way sensitivity analysis, the HCAM was re-calculated four times (with 5% and 10% discount rates, and world average life expectancy of 73.2 years and world highest life expectancy of 88.17 years) to ascertain the effect on TPV.*
Results*: The 100,875 human lives lost in India had a TPV of Int$8,163,602,456, and an average of Int$80,928 per human life. The application of 5% and 10% discount rates shrank the TPV by 16.77% and 42%, respectively. In turn, recalculation of the model with the world average life expectancy of 73.2 years and world highest life expectancy of 88.17 years grew the TPL by 22.2% and 108%.*
Conclusion:*The average TPV per human life lost to COVID-19 of Int$80,928 was nine-fold per capita GDP of India. The evidence presented demonstrates that the ongoing COVID-19 pandemic has a significant negative impact on the health and economy of India.*
Key Word*:Coronavirus; COVID-19; Gross domestic product; Value of life.*

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I. INTRODUCTION

India had an estimated population of 1,383,456,294 people in 2020 [1]. During the same year, the lower-middle-income country had a total gross domestic product (GDP) of International Dollars (Int$) 12,362.812 billion, and a per capita GDP of Int$9,026.867 [2]. India had an inequality-adjusted human development index of 0.477 in 2018 [3]. The IMF predicted that India's annual real GDP growth rate would decrease from 4.2% in 2019 to 1.9% in 2020 due to the global Coronavirus Disease (COVID-19) pandemic [4].

In 2019, before the COVID-19 outbreak, India recorded a total of 9,391,548.57 deaths from all causes. Out of which, 6,098,907.97 (64.93%) were caused by noncommunicable diseases (NCD); 2,347,896.53 (25.02%) by communicable, maternal, neonatal, and nutritional diseases (CMNND); and 944,744.07 (10.06%) by injuries [5]. Of the 2,347,897 CMNND deaths, 36.6% were from respiratory infections and tuberculosis, 30% from enteric infections, 20.4% from maternal and neonatal disorders, 2.6% from neglected tropical diseases and malaria, 2.4% from HIV/AIDS and sexually transmitted infections, 1.1% from nutritional deficiencies, and 7.0% from other infectious diseases.

As of 3 October 2020, 76,717,728 COVID-19 tests performed in India unveiled a total of 6,471,934 cases, 100,875 deaths, 5,425,077 recovered cases, and 945,982 active cases [1]. India had a lower density of COVID-19 tests of 55,454 per million population than China's 111,163 tests per million population. Furthermore, India's burden of 4,678 cases and 73 deaths per million population was higher than China's 59 cases and three deaths per million population [1]. The higher burden of COVID-19 in India might be explained by primarily four systemic factors.

First, in 2017, 27.9% of India's population was in multidimensional (health, education and standard of living) poverty compared to 3.9% in China. Also, the population living on less than Int$1.90 (i.e., below the international poverty line) in India of 21.2% was 30-fold higher than 0.7% in China [3]. Persons living below the poverty line, who often live in overcrowded shanties (informal settlements), are likely to have significant difficulty implementing public health interventions aimed at preventing community transmission of COVID-19 infections (e.g. face masks, handwashing with soap, physical distancing, lockdown, quarantine), and hospital care if infected and develops severe COVID-19 disease [6].

Second, the leadership in China may have been faster than India's in implementing a sequence of public health interventions to curb community transmission of COVID-19 following reporting of the first case in each country [7,8].

Third, as portrayed in Table 1, India's average of 13 International Health Regulations (IHR) core capacity score of 78 (on a scale of 0 to a target of 100) was 19.23% lower than 93 in China [9].

Table 1: International Health Regulations (IHR) core capacity scores for India compared to those of China

IHR capacity	India in 2019	China in 2019
Legislation and financing	100	100
Coordination and IHR national focal point functions	100	100
Laboratory	40	100
Surveillance	100	100
Human resources	100	100
National health emergency framework	80	80
Health service provision	20	100
Risk communication	80	80
Points of entry	80	100
Chemical events	80	80
Radiation emergencies	80	100
Food safety	60	100
Zoonotic events and the human-animal interface	60	100
Average of 13 IHR core capacity scores	**78**	**93**

Source: WHO [9].

In India, only four core capacities (legislation and financing, coordination and IHR national focal point functions, surveillance, human resources) were operating optimally (at the target of 100) compared to ten in China [9]. The below-average laboratory and health service provision IHR capacities clearly indicates the vulnerability of the Indian national health system on the face of COVID-19.

Fourth, as shown in Table 2, densities of health workforce [10], medical devices [11], and infrastructure [12] to the population in India were lower than those of China. The lower densities of physical health system inputs coupled with three-fold lower current health expenditure per capita contribute to the significant deficit in the population coverage of essential health services in India.

Table 2: The health system and social determinants of health indicators in India compared with those of China

Health workforce indicators (2017) [10]	**Value in India**	**Value in China**
Medical doctors per 10,000 population	7.8	19.8
Nursing and midwifery personnel per 10,000 population	21.1	26.1
Dentists per 10,000 population	1.88	4.46
Pharmacists per 10,000 population	6.79	3.17
Medical devices indicators in 2013 [11]		
Radiotherapy units per million population in 2013	0.4	1.1
Infrastructure indicators in 2017 [12]		
Hospital beds per 10,000 population	5.3	43.1
Essential medicines in 2013 [13]		
Median availability of selected generic medicines: public sector (%)	22.1	15.5
Median availability of selected generic medicines: private sector (%)	76.8	13.3
Essential health service coverage indicators [14]		
UHC index of service coverage (SCI)	55	79
UHC SCI components: Reproductive, maternal, newborn and child health	70	86
UHC SCI components: Infectious diseases	45	69
UHC SCI components: Noncommunicable diseases	64	65
UHC SCI components: Service capacity and access	46	100
Catastrophic out-of-pocket health spending (SDG indicator 3.8.2) [14,15]		
Population with household expenditures on health greater than 10% of total household expenditure or income (SDG 3.8.2) (%)	17.3	19.7
Population with household expenditures on health greater than 25% of total household expenditure or income (SDG indicator 3.8.2) (%)	3.9	5.4
Current Health Expenditure (CHE) per Capita in PPP	253.3	841.1
Domestic General Government Health Expenditure as % of CHE	27.1	56.7
Domestic Private Health Expenditure as % of CHE	72.1	43.3
Out-of-Pocket Expenditure (OOPS) as % of CHE	62.4	36.05

External Health Expenditure (EXT) as % of CHE	0.8	0.0
CHE as % Gross Domestic Product (GDP)	3.53	5.15
Domestic general government health expenditure as percentage of GDP (%)	0.96	2.92
Social Determinants of Health in 2017		
Population using improved drinking water sources (%) [16]	93.4	93.7
Population using improved sanitation facilities (%) [16]	72.0	90.7
Multidimensional poverty headcount: Population with a deprivation score of at least 33 percent (%) [3]	27.9	3.9

Sources: contained in the Table.

In 2017, the Universal Health Service Coverage Index (UHSCI) index in India of 55 (on a scale of 0 to 100 target) fell short of the target by 45% [12]. As depicted in Table 2, the deficit in India's UHSCI is explained by the sub-optimal UHCSCI component scores of 70 in reproductive, maternal, newborn and child health (RMNCH); 45 in infectious diseases (ID); 64 in non-communicable diseases (NCD); and 46 in services capacity and access (SCA). Contrastingly, China's essential health services coverage scores of 79 for UHCSCI, 86 for RMNCH, 69 for ID, 65 for NCD, and 100 for SCA were higher than those of India by 43.6%, 22.9%, 53.3%, 1.6%, and 117.4%.

According to Stenberg *et al*. [17], the lower-middle-income countries such as India, need to increase investments in the national health system to US$146 per person per year to reach United Nations Sustainable Development Goal 3 (SDG3) targets. India's current per capita health expenditure of US$69 falls short of the target by 111.6%. Therefore, the Ministry of Health ought to continuously undertake lots of evidence-based advocacy with the Ministry of Finance and the domestic private sector partners to increase health expenditure to the required target.

According to Rice and Cooper [18], "*The value of human life expressed in terms of lifetime earnings is a basic tool of the economist, program planner, government administrator, and others who are interested in measuring the social benefits associated with investments in particular programs*" (p.1954). Rice [19] advances that estimates of the value of human life are useful in quantifying the enormity of disease in dollar terms, the universal language used by those responsible for allocating public and private sectors budgets.

Lately, there have been some attempts to estimate the money value of human life losses associated with COVID-19 in Africa [20], Brazil [21], Canada [22], China [23], France [24], Germany [25], Iran [26], Italy [27], Mauritius [28], Spain [29], Turkey [30], the United Kingdom [UK] [31], and the United States of America [USA] [32] to generate evidence for use in advocacy for increased investments into health-related systems.

The review by Sandeep *et al*. [33] of the impact of COVID-19 on the primary sector (agriculture, medical industry, petrol and oil), secondary sector (information technology, finance industry, manufacturing industry), tertiary sector (education, tourism, aviation), and social fabric (domestic violence) reveals a scarcity of evidence on the monetary value of human life losses associated with COVID-19 in India. Such information is urgently needed to make a case for increased investments in health development-related systems, not only to combat ongoing COVID-19 pandemic more effectively but accelerate progress towards the SDG3 [34].

The research question of the current study was: What is the total present value of human life losses associated with COVID-19 in India? The specific study objective was to estimate the total present value of human life losses (TPV) associated with COVID-19 in India as of 3 October 2020.

II. MATERIAL AND METHODS

Ethical Approval

The research involved analysis of existing statistical secondary data contained in the freely available international databases of Worldometer[1,35], IMF [2], and WHO [14], and thus, no ethical approval was required.

Study location, design, and population

The cross-sectional study reported in this paper was conducted in India, including the 35 administrative States and union territories. It covers the period between 30 January 2020 (when the first case of COVID-19 was reported in India) and 3 October 2020 [8]. The study included a cumulative number of 100,875 deceased persons who died from COVID-19 as of 3 October 2020 [1,7].

Human Capital Approach Analytical Framework

The Organization for Economic Cooperation and Development [OECD] defined human capital as "*The knowledge, skills, competencies and attributes [health, behavior] embodied in individuals that facilitate the creation of personal, social and economic well-being (p.18)*" [36]. Oxford dictionary defines well-being as a state of being comfortable, healthy or happy [37]. In the economic theory of consumer behavior, an individual is postulated to maximize utility (happiness, satisfaction or pleasure) from the consumption of bundles of commodities (health, non-health goods and services, and leisure) subject to one's disposable income [38,39].

Individuals derive utility from good health and not from inputs such as health services and resources (time and money) spent [40]. Thus, as Feldstein [41] explains "… *the demand for medical care (which is an input in the health production function) is derived from the more basic demand for health*" (p.117).

At any age, deaths from any cause (disease or injury), terminates the embodied stock of human capital, and hence, capacity as an individual to derive utility (or happiness) from consumption of bundles of commodities (health, non-health goods and services, leisure). Also, death exterminates individual's capability to contribute positively to national market (measured by the GDP) and non-market activities (including bringing happiness to the family, caring, making love, nurturing, parenting, participating in national governance, positive role modelling, participating in cultural and religious practices, and transmitting knowledge and societal values) that are valued by society. Death stops individual's contributions to GDP permanently by ending spending on consumer goods and services, investments (usually from savings), government services (financed from tax revenues and fees), and exported goods and services (net of imports).

How do we place a monetary value on human life losses associated, for example, with COVID-19? Economists suggest three approaches [42]:

- the net output or human capital approach (HCA);
- the implicit values approach; and
- the willingness-to-pay (also called contingent values approach).

Jones-Lee [43] and Mooney [44] critically discusses the advantages and disadvantages of each approach. Due to successful recent applications in the valuation of human life losses associated with COVID-19, and availability of pertinent data on GDP per person and current health expenditure per person, we chose to apply the HCA.

Weisbrod[45] recommends that "*The present value of a man* [or woman] *at any given age may be defined operationally as his* [her] *discounted expected future earnings stream (net of his* [her] *consumption if the net concept is used)*" (p.427). Weisbrod's advice has been, more recently, echoed by Rice [19] and WHO [39]. The authors advise the application of non-health GDP per capita (or GDP per capita net of expenditure on health care per capita) because, as explained earlier, individuals do not derive utility (happiness) from consumption of health commodities (goods and services) but from improved health [40,41]. Expenditures on health services only serve to reduce the disposable income available to an individual (or a household), which could have been spent on utility yielding commodities, i.e. non-health market goods and services, and leisure activities. Therefore, consistent with Weisbrod[45], Rice [19], Rice and Cooper [18], and WHO [39] proposition, net GDP per person was used to monetarily value human life losses associated with COVID-19 in India.

The present study replicates the HCA model (HCAM) applied in our past studies in Africa [20], Brazil [21], Canada [22], China [23], France [24], Germany [25], Iran [26], Italy [27], Mauritius [28], Spain [29], Turkey [30], the UK [31], and the USA [32]. The total present value of human life losses associated with COVID-19 in India as of 3 October 2020 (TPV_{INDIA}) is the summation of the discounted present value of human life losses sustained by persons in each k[th] age group (PV_k): 1=0-14 years, 2=15-29 years, 3=30-44 years, 4=45-59 years, and 5=60 years and above. Algebraically [20-32]:

$$TPV_{INDIA} = \sum_{k=1}^{k=5} PV_k \quad \ldots\ldots (1).$$

The PV_k for k[th] age bracket was estimated by multiplying the discount factor, net GDP per person, years of life lost (YLL), and the age group's number of human lives lost to COVID-19 [20-32]. Formally [20-32]:

$$PV_k = \sum_{t=1}^{T} \{(W_1) \times (W_2 - W_3) \times (W_4 - W_5) \times (W_6 \times W_7)\} \ldots\ldots\ldots (2)$$

Where: $W_1 = 1/(1+r)^t$ is the discount factor; r is the discount rate of 3% [20-32]; $\sum_{t=1}^{T}$ is the total from year $t=1$ to T; $t=1$ is the first year of life lost (YLL) to COVID-19 and T is the final year of the sum of YLL per COVID-19 human life lost within an age bracket; W_2 is the average life expectancy at birth for India; W_3 is the average age at death from COVID-19 for k[th] age bracket; W_4 is the GDP per person for India in International Dollars (Int$); W_5 is the per capita current health expenditure in Int$ for India; W_6 is the total number of COVID-19 associated deaths reported in India as of 3 October 2020; and W_7 is the proportion COVID-19 deaths borne by the j[th] age bracket.

Data and Data Sources

The data and sources used in the India analysis were as follows:

a) Discount rates: 3%, 5%, and 10% [20-32].
b) Average life expectancy at birth in years (ALE) (W_2): India ALE = 70.42 years; global ALE = 73.2 years; Hong Kong Females ALE (world highest) = 88.17 years [35].
c) Average age at onset of death (AOD) from COVID-19 per age bracket (W_3): 0-14 years=(0+14)/2 = 7 years; 15-29 years = 22 years; 30-44 years =37; 45-59 years=52; and 60 – 74 years = 67 years (Authors estimates).
d) GDP per person for India of Int$9,026.867$(W_4)$[2].
e) Per capita current health expenditure of Int$253.32241821 for India (W_5)[14].
f) The 100,875 total COVID-19 deaths reported in India as of 3 October 2020 (W_6)[1].
g) Proportion COVID-19 deaths borne by the j^{th} age bracket (W_7): 0-14 years = 0.01; 15-29 years = 0.03; 30-44 years = 0.11; 45-59 years = 0.32; 60 years and above = 0.53 [46].
h) Proportion of COVID-19 deaths in India by states and union territories: Andaman and Nicobar Islands: 0.000525575; Andhra Pradesh: 0.058507368; Arunachal Pradesh: 0.000178497; Assam: 0.007149799; Bihar: 0.009024018; Chandigarh: 0.001675889; Chhattisgarh: 0.009936336; Dadra and Nagar Haveli and Daman and Diu: 0.0000198330060887329; Delhi: 0.053925944; Goa: 0.004383094; Gujarat: 0.034459848; Haryana: 0.014131017; Himachal Pradesh: 0.002003134; Jammu and Kashmir: 0.012018802; Jharkhand: 0.007229131; Karnataka: 0.090428591; Kerala: 0.007843954;Ladakh: 0.000604907; Madhya Pradesh: 0.023521945; Maharashtra: 0.371670534;Manipur: 0.000684239; Meghalaya: 0.000515658; Mizoram: 0; Nagaland: 0.000168581; Odisha: 0.00867694; Puducherry: 0.00527558; Punjab: 0.034717677; Rajasthan: 0.015033419; Sikkim: 0.000406577; Tamil Nadu: 0.095724004; Telengana: 0.011433728; Tripura: 0.002865869; Uttarakhand: 0.006306896; Uttar Pradesh: 0.058675949; West Bengal: 0.05027667 [47].

Statistical analysis

The HCA model was estimated using Excel Software (Washington D.C., Microsoft). The analysis involved four steps. First, calculation of the undiscounted years of life lost (UDYLL) for each of the age groups: 1=0-14 years, 2=15-29 years, 3=30-44 years, 4=45-59 years, and 5=60 years and above. As shown in Table 3, UDYLL were calculated by subtracting the AOD per age bracket (W_3) from India's ALE (W_2).

Table 3. Undiscounted years of life (YLL) lost per bereaved person by age group from COVID-19 in India

Age bracket in years	(A) Average life expectancy at birth (in years) for India*	(B) Age at onset of death**	(C) Undiscounted years of life lost per person [C=A-B]**	(D) Number of COVID-19 deaths per age bracket	(E) Sub-Total undiscounted YLL [E=C x D]
0-14	70.42	7	63.42	1,009	63,975
15-29	70.42	22	48.42	3,026	146,531
30-44	70.42	37	33.42	11,096	370,837
45-59	70.42	52	18.42	32,280	594,598
60 years and above	70.42	67	3.42	53,464	182,846
TOTAL				**100,875**	**1,358,786**

Second, estimation of the discounted years of life lost (DYLL) for each of the age groups through the multiplication of a UDYLL by the respective discount factor. For example, the discounted value for:

- first UDYLL in age bracket 0-14 = Discount factor x UDYLL = $[1/(1+0.03)^1]$ x 1 UDYLL = 0.970873786 x 1 = 0.970873786;
- tenth UDYLL in age bracket 0-14 = Discount factor x UDYLL = $[1/(1+0.03)^{10}]$ x 1 UDYLL = 0.744093915 x 1 = 0.744093915;
- sixty-third UDYLL in age bracket 0-14 = Discount factor x UDYLL = $[1/(1+0.03)^{63}]$ x 1 UDYLL = 0.155329822 x 1 = 0.155329822.

Table 4 presents the discounted years of life lost due to COVID-19 in India, which were estimated using a similar procedure as the example above, at 3%, 5% and 10% discount rates.

Table 4. Discounted potential years of life lost due to COVID-19 in India

Age bracket in years	Sub-total undiscounted years of life lost (UDYLL)	YLL discounted at 3%	YLL discounted at 5%	YLL discounted at 10%
0-14	63,975	28,402	19,242	10,063
15-29	146,531	76,463	54,706	29,951
30-44	370,837	230,422	177,568	106,185
45-59	594,598	443,963	377,340	264,742
60 years and above	182,846	151,228	145,595	132,956
TOTAL	**1,358,786**	**930,479**	**774,451**	**543,896**

Third, appraisal of the net GDP per capita by subtracting the current health expenditure per person (W_5) from the GDP per capita (W_4) for India. Net GDP per capita = $W_4 - W_5$ = Int$9,026.867 - Int$253.32241821 = Int$8,773.54.

Fourth, assessment of COVID-19 deaths accruing to each of the five age brackets, through the multiplication of the total COVID-19 deaths reported in India as of 3 October 2020 (W_6) by the respective proportion (W_7). Thus, the number of deaths borne by each age group equals:

- 0-14 years bracket = $W_6 \times W_7 = 100{,}875 \times 0.01 = 1{,}009$;
- 15-29 years bracket = $W_6 \times W_7 = 100{,}875 \times 0.03 = 3{,}026$;
- 30-44 years = $W_6 \times W_7 = 100{,}875 \times 0.11 = 11{,}096$;
- 45-59 years = $W_6 \times W_7 = 100{,}875 \times 0.32 = 32{,}280$;
- 60 years and above = $W_6 \times W_7 = 100{,}875 \times 0.53 = 53{,}464$.

Fifth, estimation of $PV_{j=1,2,3,4,5}$ by multiplying the discounted YLL lost per person in an age group, net GDP per capita, and the age group's number of human lives losses associated with COVID-19. As an example, for 45-59 age bracket, the discounted YLL per person = 13.75351308; net GDP per capita = Int$8,773.54; and number of deaths in age 45-59 age group = 32,280. Therefore, the present value of human lives lost due to COVID-19 in 45-59 years age bracket (PV_{45-59}) $= 13.75351308 \times 8{,}773.54 \times 32{,}280 = 3{,}895{,}132{,}702$. The $PV_{1,2,3,5}$ for the other four age brackets were estimated similarly.

Sixth, each state's share of TPV was estimated by multiplying TPV estimate by the respective proportion of COVID-19 deaths.

Seventh, a one-way sensitivity analysis was performed by re-calculating the HCAM four times with 5% discount rate, 10% discount rate, world average life expectancy at birth of 73.2 years, and world highest life expectancy at birth of 88.17 years, i.e. the Hong Kong female average life expectancy at birth [20-32]. The sensitivity analysis was conducted holding all the other parameters constant to evaluate the impact of changing each discount rate and average life expectancy on the estimated TPV_{INDIA}.

III. RESULT

Findings from analysis assuming India's mean life expectancy of 70.42 years and a discount rate of 3%

As of 3 October 2020, India incurred a loss of 100,875 human lives due to COVID-19, which were equivalent to 1,358,786 undiscounted YLL, i.e. 930,479 discounted YLL. As depicted in Table 5, the total number of human lives lost in India had a total present value (TPV) of Int$8,163,602,456, and an average of Int$80,928 per human life.

Table 5: The total and average present value of human lives lost to COVID-19 in India – assuming India's average life expectancy at birth and a discount rate of 3% (in 2020 Int$)

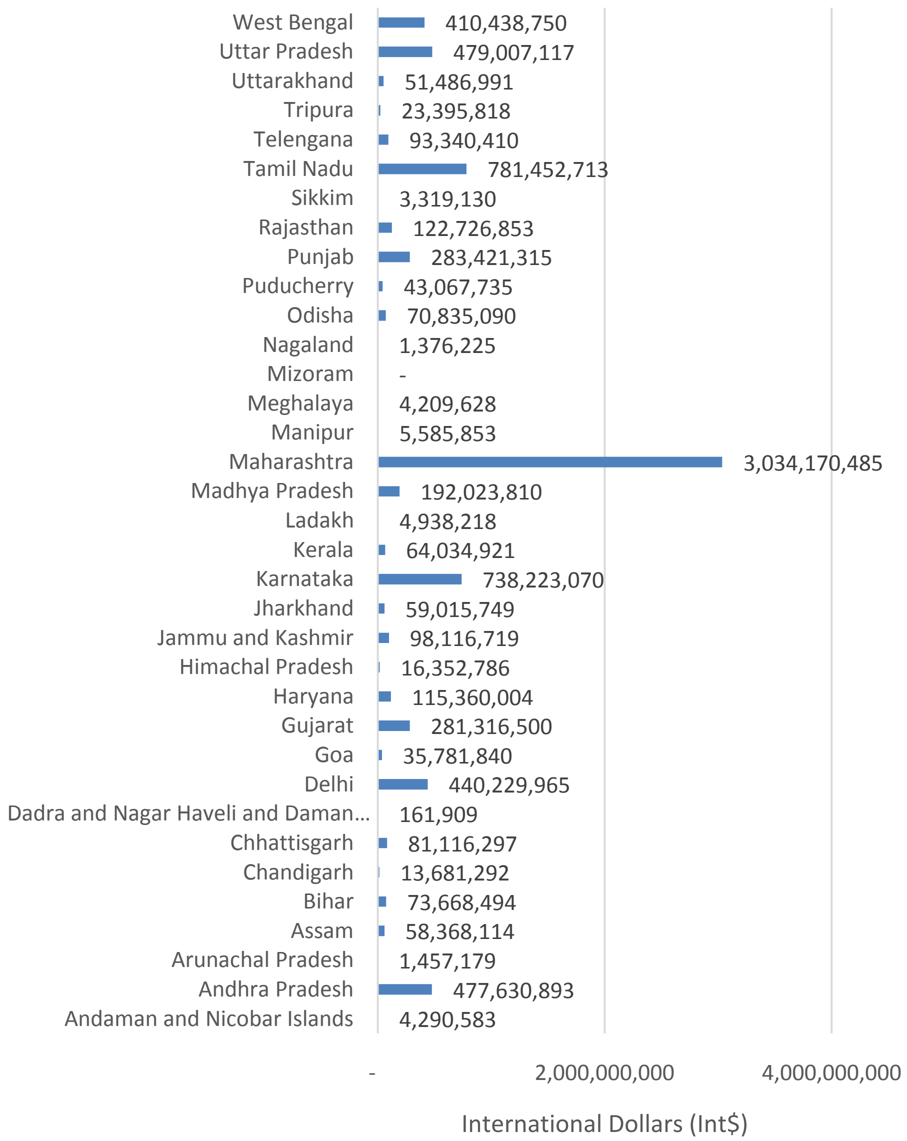
Age group (in years)	Value of human lives lost at 3% discount rate (Int$)	Average value per human life in an age group (Int$)
0-14	249,186,518	247,025
15-29	670,854,794	221,679
30-44	2,021,621,348	182,190
45-59	3,895,132,702	120,667
60 & above	1,326,807,094	24,817
Total	**8,163,602,456**	**80,928**

About 3.05% of the TPV accrued to 0-14-year-olds, 8.22% to 15-29-years-olds, 24.76% to 30-44-year-olds, 47.71% to 45-59-year-olds, and 16.26% to 60-year-olds and above. The persons aged between 15 years and 59 years, i.e. the most economically productive bracket, bore 80.69% of the TPV. The mean TPV diminishes as the age of the deceased advances, e.g. the 0-14-year-olds mean present value of Int$247,025 was ten-fold higher than Int$24,817 among the 60-year-olds and above.

Share of the TPVHL by States and union territories in India

Figure 1 portrays the share of the TPV across the States and Union Territories.

Figure 1: State and union territories share of the present value of human lives lost from COVID-19 in India as of 3 October 2020 (Int$,2020)



The magnitude of TPV in the States and Union Territories varied widely between Int$0 in Mizoram (which had no recorded death from COVID-19) to Int$3,034,170,485 in the State of Maharashtra. Fourteen countries incurred Int$50 million and below; nine countries incurred Int$51-100 million; two countries incurred Int$101-150 million; ten countries incurred Int$151 million and above. Five states (Andhra Pradesh, Karnataka, Maharashtra, Tamil Nadu, and Uttar Pradesh) bore 67.50% of the TPV. The magnitude of TPV borne by a State is dependent on the number of COVID-19 deaths sustained.

Sensitivity Analysis: Impact of Changes in the Discount Rate

Table 6 shows that the application of 5% and 10% discount rates in the HCAM, holding all other parameters constant, shrank the TPV by Int$1,368,920,419 (16.77%) and Int$3,391,706,571 (42 %), respectively. In turn, the average TPV per human life lost diminished by Int$13,570 and Int$33,623.

Table 6: Impact of application of 5% and 10% discount rates on the total present value of human lives lost to COVID-19 in India (in 2020 Int$)		
Age group (in years)	**Value of human lives lost at 5% discount rate (Int$)**	**Value of human lives lost at 10% discount rate (Int$)**
0-14	168,820,431	88,284,748
15-29	479,965,520	262,772,669
30-44	1,557,903,279	931,617,198
45-59	3,310,608,130	2,322,722,078
60 & above	1,277,384,678	1,166,499,194
TOTAL	**6,794,682,038**	**4,771,895,886**

Sensitivity Analysis: Effect of Changes in the Life Expectancy

As shown in Table 7, a rerun of the HCAM with the world average life expectancy of 73.2 years and the world highest life expectancy of 88.17 years separately, grew the TPL by Int$1,810,659,854 (22.2%) and Int$8,803,943,299 (108 %). In turn, the average TPL increased by Int$17,950 and Int$87,276, respectively.

Table 7: Impact of changes in average life expectancy on the total present value of human life losses associated with COVID-19 in India (in 2020 Int$)		
Age group (in years)	**Value of human lives lost: using world mean life expectancy of 73.2 years (Int$)**	**Value of human lives lost: using world highest mean life expectancy of 88.17 years (Int$)**
0-14	253,075,060	268,093,714
15-29	689,029,458	759,225,179
30-44	2,125,444,972	2,526,441,345
45-59	4,365,689,280	6,183,112,647
60 & above	2,541,023,540	7,230,672,870
TOTAL	**9,974,262,310**	**16,967,545,755**

IV. DISCUSSION

Key Findings

- The 100,875 human lives lost to COVID-19 had a TPV of Int$8,163,602,456, which was equivalent to 0.07% of India's total GDP in 2020.
- The average TPV per human life of Int$80,928 was nine-fold per capita GDP of India.
- The application of 5% and 10% discount rates shrank the TPV by Int$1,368,920,419 (16.77%) and Int$3,391,706,571 (42 %), respectively.

As demonstrated in related studies, as discount rate increases, the TPV diminishes [20-32]. Also, the use of the world mean life expectancy of 73.2 years and the world highest life expectancy of 88.17 years, which are 2.78 and 17.75 years higher than India's national life expectancy, augmented the TPV.

Comparison with COVID-related Value of Life Studies

The average TPV per human life in India of Int$80,928 was lower than Int$99,629 in Brazil [21]; Int$231,217 in Canada [22]; Int$356,203 in China [23]; Int$339,381 in France [24]; Int$132,960 in Germany [25]; Int$165,187 in Iran [26]; Int$369,088 in Italy [27]; Int$312,069 in Mauritius [28]; Int$470,798 in Spain [29]; Int$228,514 in Turkey [30]; Int$225,104 in the UK [31]; and Int$292,889 in the USA [32]. Therefore, mean TPV per human life for India was lower than that of Brazil by 23%, Canada by 186%, China by 340%, France by 319%, Germany by 64%, Iran by 104%, Italy by 356%, Mauritius by 286, Spain by 482%, Turkey by 182%, the UK by 178%, and the USA by 262%.

Limitations of the Study

First, the completeness of cause-of-death data in India was 10% in 2017 48], and therefore, the cumulative number of human lives lost due to COVID-19 might be under-reported. Thus, the TPV results might be a gross under-estimate.

Second, the GDP per capita used to value YLL due to COVID-19 has some shortcomings. Stiglitz, Sen, &Fitoussi[49] have criticized per capita GDP as an imperfect indicator of economic performance and social progress because it does not reflect quality-of-life (or wellbeing), income and wealth inequalities and inequities, and negative externalities of economic production processes, e.g. destruction of the ecosystem, air pollution, and global warming leading to climate change.

Third, various studies have castigated the standard HCA method of valuing human life for attaching no monetary value to YLL among the retired, children below legal working age, homemakers, unemployed, and persons not employed due to severe physical and mental handicap [19,42,43]. Given that the UN Universal Declaration of Human Rights [51] and the WHO Constitution [52] indicates that all persons have right to life, health, and health care, YLL among all age groups was valued at the same net GDP per capita in the current study.

Suggestions for further research

There is a need for further research into:

a) Innovative applications of information technology to improve the vital registration system and national health information system to improve the completeness of cause-of-death data in India.

b) Factors that determine individuals and households demand for preventive, curative (management) and rehabilitative interventions against COVID-19; and analysis of individual's choice to practice handwashing with soap and adhere to bans, lockdowns, social distancing, voluntary quarantine, and proper use of face masks (among other public health measures) to prevent (or reduce) community transmission of COVID-19. Such knowledge would enable health policymakers to explain variations in the utilization of COVID-19-related health-related services across and within administrative states and population groups [41]. Also, the demand analysis evidence can be used to forecast demand for COVID-19 interventions accurately; and inform the design of policy measures to boost demand for underutilized interventions/services.

c) Cost of preventive, curative (management) and rehabilitative interventions against COVID-19 for use in planning and budgeting.

d) Cost-benefit analysis of alternative preventive, curative (management) and rehabilitative interventions against COVID-19 to guide health policy development, planning, and decision-making [53,54].

V. CONCLUSION

The average present value per human life lost to COVID-19 of Int$80,928 was nine-fold per capita GDP of India. The evidence presented in this paper demonstrates that the ongoing COVID-19 pandemic has a significant negative impact on the health and economy of India. Thus, economic losses associated with loss of human lives compounds the negative impacts of COVID-19, discussed by Sandeep *et al.*[33], on the primary sector, secondary sector, tertiary sector, and social fabric.

In order to reduce (or mitigate) the probability of occurrence (and recurrence) of public health emergencies (such as COVID-19), and hence, avert premature loss of life and recalcitrant destruction of livelihoods and way of life, India ought to make efficient investments to create resilient national health-related systems aimed at attaining universal coverage of essential services, while maintaining the trajectory for the achievement of SDG3 by 2030 [34]. Given the scarcity of national resources, amidst unlimited competing multisectoral needs, the health sector leadership ought to use the kind of economic evidence contained in this paper in conjunction with arguments of assuring every person's right to life (Article 3) and health services (plus clothing, food, housing and social security) (Article 25) [51], to mount sustained advocacy for multisectoral investments to bridge existing deficits in IHR core capacities, and coverage of essential health services, and safe drinking water and sanitation services.

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AUTHORS' CONTRIBUTIONS

JMK, RNDKM, LHKN, and NGM designed the study; reviewed the literature; extracted data from the international databases; analyzed and interpreted findings; and drafted the manuscript together. All the authors approved the version of the manuscript submitted.

CONFLICT OF INTEREST

The authors declare that they have no actual or potential conflict interests.

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