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The present value of human life losses associated with Covid-19 in Japan

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Abstract:
Background*: As of 29 October 2020, Japan had a total of 98,116 Coronavirus Disease (COVID-19) cases that included 1,730 (1.8%) deaths, 90,807 (92.6%) recovered cases, and 5,579 (5.7%) active cases. The ongoing pandemic continues to disrupt external trade and supply chains, and all other economic and social sectors in the country. The aim of this study was to assess the total present value of human life losses [TPVHL] associated with COVID-19 in Japan.*
Materials and Methods*: The human capital methodology was applied (assuming a discount rate of 3% and Japan's life expectancy of 85.03 years) to assess the total present value of 1,730 human life losses associated with COVID-19 in Japan as of 29 October 2020. Robustness of the findings was tested using 5% and 10% discount rates, and the average global life expectancy of 73.2 years and the highest world life expectancy of 88.17 years.*
Results*: The TPVHL was Int$496,463,298, and value per human life was Int$286,973. Recalculation of the model with 5% and 10% discount rates, holding all the other parameters constant, reduced the TPVHL by 11.8% and 31.8%, respectively. Reanalysis of the model with the global average life expectancy at birth reduced the TPVHL by 80.7%; while the use of the world highest life expectancy at birth increased the TPVHL by 28%.*
Conclusion:*This evidence would be useful to the Ministry of Health, Labour and Wealth when advocating for increased investments into health-related systems to bridge the limited existing gaps in Universal Health Coverage, International Health Regulations capacities, and water and sanitation coverage.*
Key Word*:COVID-19; Coronavirus; Gross Domestic Product; Human Capital Approach; Value of Life.*

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I. INTRODUCTION

Japan is a member of the seven major advanced economies group, also referred to as G-7 countries, which also include Canada, France, Germany, Italy, the United Kingdom [UK], and the United States of America [USA]. Japan has a population of 126,349,596 people [1]; a total gross domestic product (GDP) of International Dollars (Int$) 5,236.138 billion [2]; a per capita GDP of Int$41,636.628 [2]; a very high human development index (HDI) of 0.915, which diminished to 0.882 after adjustment of inequality [3]; and a Gini Coefficient of 32.1 (measured on a scale of 0, where all persons in a country have an equal income, and 100%, where one person own the entire national income) [3]. Approximately 20.3% of national income belongs to the poorest 40% population compared to 24.7% possessed by the richest 10% and 10.4% held by the richest 1% (3). The IMF predicts a -5.2% decline in real GDP growth in Japan in 2020 [4].

As of 29 October 2020, Japan had a total of 98,116 Coronavirus Disease (COVID-19) cases that included 1,730 (1.8%) deaths, 90,807 (92.6%) recovered cases, and 5,579 (5.7%) active cases [1]. The total number of COVID-19 test is 2,633,603. The density is 20,844 tests per million population, 777 total cases per million population, and 14 deaths per million population. The number of COVID-19 cases and deaths per a million population are far much smaller than those of the other six G-7 countries [1]. Why?

First, as depicted in Table 1,the average of 13 International Health Regulations (IHR) core capacity score of Japan of 95 in 2019 was lower than 99 in Canada but higher than those 82 in France, 88 in Germany, 85 in Italy, 93 in the UK, and 92 in the USA [5]. In Japan, the IHR capacities of legislation and financing, coordination and national focal points, laboratory, surveillance, national health emergency framework, health service provision, points of entry, chemical events, radiation emergencies, food safety, and zoonotic and the human-animal interface had attained target scores of 100. It was only the IHR capacities of human resources and risk communication that had sub-optimal scores of 80% and 60%, respectively [5].

Table 1: Comparison of International Health Regulations core capacity scores of Japan against those the six other G-7 countries

IHR capacities	Japan	Canada	France	Germany	Italy	UK	USA
Legislation & financing	100	100	100	100	100	100	100
Coordination & national focal point functions	100	100	100	100	100	100	100
Laboratory	100	100	100	100	100	100	100
Surveillance	100	100	100	100	100	100	100
Human resources	80	100	80	80	80	100	60
National health emergency framework	100	100	100	100	100	100	100
Health services	100	100	100	100	100	100	100
Risk communication	60	100	80	60	60	100	100
Points of entry	100	100	40	60	80	40	100
Chemical events	100	100	100	80	60	80	80
Radiation emergencies	100	100	100	100	80	100	80
Food safety	100	100	80	80	80	100	100
Zoonotic events & the human–animal interface	100		80	100	100	100	80
AVERAGE SCORE	**95**	**99**	**82**	**88**	**85**	**93**	**92**

Source: WHO [5].

Second, as portrayed in Table 2, in 2017, the Universal Health Coverage index of service coverage (UHCSCI) for Japan of 83 was equal to that of Germany but higher than those of France and Italy by 6.0% and 1.2%, respectively [6]. However, Japan's UHCSCI was lower than those of Canada, the UK, and the USA by 7.2%, 4.8%, and 1.2%. Japan's constituent UHCSCI components of reproductive, maternal, newborn and child (RMNCH) had a score of 85; infectious diseases (IDS) had a score of 79, noncommunicable diseases (NCD) had a score of 71, and service capacity and access (SCA) had an optimal score of 100. Thus, the deficit of 17 in Japan's overall UHCSCI was due to shortfalls of 15, 21, and 29 in constituent components of RMNCH, IDS, and NCD.

Table 2: The health system and social determinants of health indicators in Japan compared to those of the six other G-7 countries

Health workforce indicators (2018) [7]	**Japan**	**Canada**	**France**	**Germany**	**Italy**	**UK**	**USA**
Medical doctors per 10,000 population	24.1	23.1	32.7	42.5	39.8	28.1	26.1
Nursing and midwifery personnel per 10,000 population	121.5	99.4	114.7	132.4	57.4	81.7	145.5
Dentists per 10,000 population	8.0	6.4	6.7	8.5	8.2	5.2	5.8
Pharmacists per 10,000 population	18.0	11.2	10.6	6.5	10.9	8.9	9.2
Medical devices indicators in 2013 [8]	**Japan**	**Canada**	**France**	**Germany**	**Italy**	**UK**	**USA**
Computed tomography units (per million population)	101.2	13.8	N/A	N/A	N/A	N/A	N/A
Radiotherapy units per million population in 2013	7.2	8.1	7.5	6.4	6.4	5.0	12.4
Mammography units (per million females aged 50–69 years)	227.3	N/A	N/A	N/A	N/A	N/A	N/A
Infrastructure indicators in 2018 [7]	**Japan**	**Canada**	**France**	**Germany**	**Italy**	**UK**	**USA**
Hospital beds per 10,000 population	129.8	25.2	59.1	80	31.4	24.6	28.7
Essential health service coverage indicators in 2017 [9]	**Japan**	**Canada**	**France**	**Germany**	**Italy**	**UK**	**USA**
UHC index of service coverage (SCI)	83	89	78	83	82	87	84
UHC SCI components: Reproductive, maternal, newborn and child health	85	94	96	94	86	92	90
UHC SCI components: Infectious diseases	79	82	71	79	82	86	81
UHC SCI components: Noncommunicable diseases	71	81	56	64	67	74	68
UHC SCI components: Service capacity and access	100	100	96	99	96	96	100
Catastrophic out-of-pocket health spending (SDG indicator 3.8.2) (WHO, 2020c, 2020d)	**Japan**	**Canada**	**France**	**Germany**	**Italy**	**UK**	**USA**

Population with household expenditures on health greater than 10% of total household expenditure or income (SDG 3.8.2) (%) [7]	4.36	2.64	1.42	1.72	9.29	1.6	4.77
Population with household expenditures on health greater than 25% of total household expenditure or income (SDG indicator 3.8.2) (%) [7]	0.61	0.51	0.22	0.11	1.08	0.48	0.78
Current Health Expenditure (CHE) per Capita in PPP [10]	4,563	4,929	5,011	5,923	3,620	4,338	10,246
Domestic General Government Health Expenditure as % of CHE [10]	84.09	73.72	77.09	77.66	73.90	79.41	50.16
Domestic Private Health Expenditure as % of CHE [10]	15.91	26.28	22.91	22.34	26.10	20.58	49.84
Out-of-Pocket Expenditure (OOPS) as % of CHE [10]	12.85	14.22	9.38	12.67	23.49	15.96	10.99
CHE as % Gross Domestic Product (GDP) [10]	10.94	10.57	11.31	11.25	8.84	9.63	17.06
Domestic general government health expenditure as percentage of GDP (%) [10]	9.20	7.79	8.72	8.73	6.53	7.65	7.65
Social Determinants of Health in 2018	**Japan**	**Canada**	**France**	**Germany**	**Italy**	**UK**	**USA**
Proportion of population using safely-managed drinking-water services (%) [7]	98	99	98	>99	95	>99	>99
Proportion of population using safely-managed sanitation services (%) [7]	99	82	88	97	96	98	90
Gini Index (coefficient) [3]	32.1	34.0	32.7	31.7	35.4	33.2	41.5

About 770,733 (0.61%) of the population has household expenditures on the health of greater than 25% of total household income in Japan (6), which imply exposure to a high risk of financial catastrophe [7]. The 2,526,992 (98%) and 1,263,496 (99%) of the population without access to safely managed drinking water and sanitation will have some challenge exercising personal hygiene, and especially practising regular handwashing to prevent COVID-19 infection and transmission [7].

According to Rice [11], "*cost of illness studies are used by policymakers to justify budgets, to prioritize funding in biomedical research, and to develop intervention programs to ameliorate or prevent a disease*" (p.178). Card and Mooney [12] explains that the monetary valuation of human life makes decision-making more rational, explicit, and efficient. Thus, evidence on the monetary value of human life can potentially be used by health policymakers to advocate (campaign) for increased investments into health-related systems to bridge the persisting narrow gaps in UHC, IHR, and water and sanitation coverage.

In the context of COVID-19, such evidence currently exists in Africa [13], Brazil [14], Canada [15], China [16], France [17], Iran [18], Italy [19], Mauritius [20], Spain [21], Turkey [22], the UK [23], and the USA [24]. However, there is a paucity of such evidence in Japan. This study assesses the total present value of human life losses associated with COVID-19 in Japan as of 29 October 2020.

II. MATERIAL AND METHODS

Study Design and Location

This cross-sectional study of monetary value of life was conducted in Japan and all its 47 Prefectures of Aichi, Akita, Aomori, Chiba, Ehime, Fukui, Fukuoka, Fukushima, Gifu, Gunma, Hiroshima, Hokkaido, Hyogo, Ibaraki, Ishikawa, Iwate, Kagawa, Kagoshima, Kanagawa, Kochi, Kumamoto, Kyoto, Mie, Miyagi, Miyazaki, Nagano, Nagasaki, Nara, Niigata, Oita, Okayama, Okinawa, Osaka, Saga, Saitama, Shiga, Shimane, Shizuoka, Tochigi, Tokushima, Tokyo, Tottori, Toyama, Wakayama, Yamagata, Yamaguchi, and Yamanashi. The duration of the study is between 16 January 2020 (when the first COVID-19 case was confirmed) and 29 October 2020. The study included all the 1,730 persons deceased due to COVID-19, and thus, sampling was not applicable [1].

An empirical framework for assessing the net present value of human life

The human capital methodology (HCM) has been applied recently in the valuation of human lives lost due to COVID-19 in Africa [13], Brazil [14], Canada [15], China [16], France [17], Iran [18], Italy [19], Mauritius [20], Spain [21], Turkey [22], the UK [23], and the USA [24]. The same HCM is replicated to assess the total net present value of human life losses associated with COVID-19 in Japan as of 29 October 2020. According to Murray [25], premature death from any cause (including COVID-19) results in years of life lost (YLL), which is the difference between potential limit of life and the age at death. In this study, we assumed the potential limit of life was the national life expectancy at birth for Japan, and thus, YLL equals Japan's life expectancy at birth, minus the age at death for the age group [13-24].

According to Weisbrod [26], Landefeld and Seskin [27], WHO [28] and Chisholm *et al.* [19], the YLL are valued monetarily at the discounted expected market earnings (whose proxy is GDP per capita), which are forgone by society due to death, net of claims on future health care consumption. Therefore, each YLL lost is valued into money using Japan's GDP per capita net of Japan's current health expenditure per person.

Japan's total net present value of human life losses associated with COVID-19 $(TPVHL_{JAPAN})$ equals the sum of the discounted value of human life losses amongst persons in age groups $(PVHL_i)$: 1=9 years and younger, 2=10 to 19 years, 3=20 to 29, 4=30 to 39 years, 5=40 to 49 years, 6=50 to 59 years, 7=60 to 69 years, 8=70 to 79 years, 9=80 years and older [13-24]. Formulaically:

$$TPVHL_{JAPAN} = \sum_{i=1}^{i=9} PVHL_{JAPAN} \dots \dots . (1)$$

The $PVHL_i$ for each of the nine age groups was appraised as follows [13-24]:

$$PVHL_{i=1,,9} = \sum_{\varphi=1}^{\varphi=m} (V_1) \times (V_2 - V_3) \times (V_4 - V_5) \times (V_6 - V_7) \dots \dots . (2)$$

Where: $\sum_{\varphi=1}^{\varphi=m}$ is the totaling from year one (φ=1) to the last YLL (φ=m); V_1 is the discount factor, i.e., $1/(1+r)^m$, where r is the discount rate of 3% used; V_2 is the GDP per person in Japan; V_3 is the current health expenditure per person in Japan; V_4 is the mean life expectancy at birth for Japan; V_5 is the mean life expectancy at death in the φ^{th} age group; V_6 is the total COVID-19 deaths in Japan as of 29 October 2020; V_7 is the proportion of total deaths from COVID-19 in the φ^{th} age group.

The $TPVHL_{JAPAN}$ was multiplied by the proportion of COVID-19 deaths to obtain the share for each of the 47 prefectures in Japan. That is:

$$PVHL_j = TPVHL_{JAPAN} \times (V_8/V_6) \dots . . (3)$$

Where: $PVHL_j$ is the portion of $TPVHL_{JAPAN}$ accruing to j^{th} prefecture; V_6 is the total number of COVID-19 deaths in Japan as of 29 October 2020; V_8 is the number of COVID-19 deaths borne by j^{th} prefecture. Equations 1, 2 and 3 were built into Excel software (Microsoft, Washington, D.C.) spreadsheets to facilitate the analysis while assuming 2020 as the base year.

The sensitivity analysis

The analysis reported in this paper had two uncertainties. One, there is no consensus in the health economics literature regarding the ideal discount rate [30,31]. Therefore, a discount rate of 3% was applied because of its extensive use in health-related guidelines [32] and studies [13-24]. Two, the global burden of disease studies assumes the potential limit to life to be the highest life expectancy in the world [25]. However, in this study, we assumed the potential limit to life to be Hong Kong's female average life expectancy at birth, which is the highest in the work [13-24].

In this study, one-way sensitivity analysis [33] was conducted to ascertain the impact on the $TPVHL_{Japan}$. It entailed recalculation of the HCM model:

1. Using a discount rate of 5% instead of 3%, while holding Japan's mean life expectancy of 85.03 years constant [34].
2. Employing a discount rate of 10%, while Japan's mean life expectancy was held constant.
3. Applying the global mean life expectancy of 73.2 years [34], while maintaining the discount rate constant at 3%.
4. Utilising the world's highest mean life expectancy of 88.17 years (for Hong Kong) [34], while holding a discount rate constant at 3%.

Data and sources

The data from the sources contained in Table 3 was used to estimate the HCM model.

Table 3: Data and data sources for the Japan value of human life assessment

Variable	Data	Data sources
Discount rate (r)	3%, 5%, 10%	Kirigia, Muthuri,Nkanata&Muthuri [13,14,17,19]; Kirigia, Muthuri&Nkanata[18,22]; Kirigia&Muthuri [15,16,21,23,24]; Musango, Nundoochan&Kirigia [20]; Attema, Brouwer& Claxton [32].
GDP per person in	Int$41,636.628	IMF [2].

Japan (V_2)		
Current health expenditure per person in Japan (V_3)	Int$4,563.46	WHO [10].
Mean life expectancy at birth (LE) (V_4)	Japan LE = 85.03 years [34]; average global LE = 73.2 years [34]; Hong Kong Females LEB (world's highest) = 88.17 years [34].	Worldometer [34].
Mean age of onset of death in φ^{th} age group (V_5)	0-9 years = (0+9)/2=4.5 years; 10-19 years = 14.5 years; 20-29 years = 24.5 years; 30-39 years = 34.5 years ; 40-49 years = 44.5 years; 50-59 years =54.5 years; 60-69 years = 64.5 years; 70-79 years = 74.5 years; 80 years & older = 85 years.	Authors estimates from age groups in Statista Research Department [35].
Total number of COVID-19 deaths in Japan as of 29 October 2020 (V_6)	1730	Worldometer [1].
Proportion of COVID-19 deaths per age group in Turkey (V_7)	0-9 years = 0; 10-19 years = 0; 20-29 years = 0.001308044; 30-39 years = 0.003924133; 40-49 years = 0.011118378; 50-59 years = 0.033355134; 60-69 years = 0.100719424; 70-79 years = 0.263570961; 80 years and older = 0.586003924.	Statista Research Department [35].
Proportion of COVID-19 deaths per Prefecture	Aichi = 0.05398619; Akita = 0; Aomori = 0.000627746; Chiba = 0.04519774; Ehime = 0.003766478; Fukui = 0.00690521; Fukuoka = 0.062146893; Fukushima = 0.001883239; Gifu = 0.006277464; Gunma = 0.011927181; Hiroshima = 0.001883239; Hokkaido = 0.067168864; Hyogo = 0.037037037; Ibaraki = 0.011299435; Ishikawa = 0.02950408; Iwate = 0; Kagawa = 0.001255493; Kagoshima = 0.007532957; Kanagawa = 0.089767734; Kochi = 0.002510986; Kumamoto = 0.005021971; Kyoto = 0.016321406; Mie = 0.004394225; Miyagi = 0.001255493; Miyazaki = 0.000627746; Nagano = 0.000627746; Nagasaki = 0.001883239; Nara = 0.005649718; Niigata = 0; Oita = 0.001255493; Okayama = 0.000627746; Okinawa = 0.028876334; Osaka = 0.134965474; Saga = 0; Saitama = 0.064030132; Shiga = 0.005021971; Shimane = 0; Shizuoka = 0.001255493; Tochigi = 0.000627746; Tokushima = 0.005649718; Tokyo = 0.256748274; Tottori = 0; Toyama = 0.016321406; Wakayama = 0.002510986; Yamagata = 0.000627746; Yamaguchi = 0.001255493; Yamanashi = 0.003766478.	Statista Research Department [36].

Ethical considerations

The study did not involve human subjects, and thus, consent for participation was no applicable. The study analysed secondary statistical data from publicly available international databases [1,2,10,34].

III. RESULTS

Analysis assuming Japan's both sexes life expectancy of 85.03 years and a 3% discount rate

The 1,730 human life losses associated with COVID-19 had a TPVHL of Int$496,463,298; and a present value of Int$286,973 per human life (Table 4).Out of the TPVHL, 0% accrued to those aged 0-9 years, 0% to 10-19 years, 0.5% to 20-29 years, 1.3% to 30-39 years, 3.4% to 40-49 years, 8.6% to 50-59-years, 20.0% by 60-69 years, 31.5% to 70-79 years, and 34.7% to 80 years and older. About 86.2% of the TPVHL accrued to people aged 60 years and above. The present value per human life lost among 30-39-year-olds was 5.7 times that of 80-year-olds and above.

Table 4: The total and average present value of human life losses from COVID-19 in Japan – assuming the national mean life expectancy of 85.03 years and a 3% discount rate (in 2020 Int$)

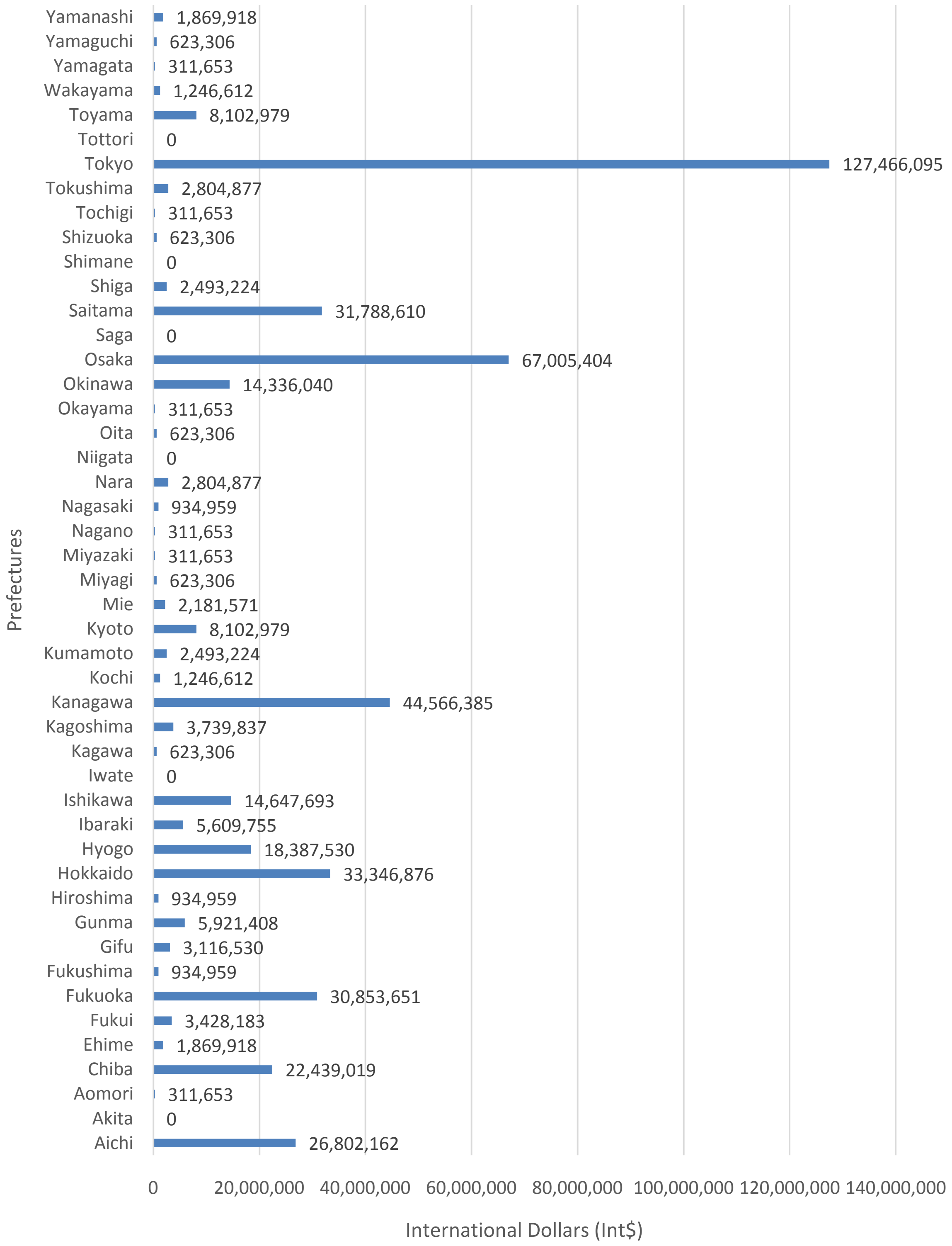
Age group in years	Present value of human lives lost at 3% discount rate (Int$)	Average present value per human life lost in an age group (Int$)
0-9*	0	0
10-19*	0	0
20-29	2,335,625	1,032,130
30-39	6,531,418	962,094
40-49	16,695,261	867,972
50-59	42,786,605	741,479
60-69	99,577,973	571,484
70-79	156,411,369	343,024
80 & older	172,125,047	169,784
TOTAL	**496,463,298**	**286,973**

Note: *Present value for those aged 0-9 years and 10-19 years was zero because there were no COVID-19 deaths in these age groups.

Disaggregation of TPVHL by prefecture

Figure 1 shows the distribution of the total present value of human life losses associated with COVID-19 in Japan by the 47 prefectures.

Figure 1: Share of total present value of human life losses associated with COVID-19 in Japan by prefecture (Int$ 2020)



Six prefectures (Akita, Iwate, Niigata, Saga, Shimane, and Tottori) had recorded zero death from COVID-19 as of 29 October 2020, and hence, had zero TPVHL. In the remaining 41 prefectures, the TPVHL varied widely from Int$311,653 (in Aomori, Miyazaki, Nagano, Okayama, Tochigi, Yamagata) to Int$127,466,095 in Tokyo. Out of the latter prefectures, 14 (29.8%) had TPVHL of less than Int$1 million; 16 (34%) had Int$1 million to Int$10 million; 11 (23.4%) had above Int$10 million. Five prefectures (Hokkaido, Kanagawa, Osaka, Saitama, and Tokyo) alone accounted for 61% of the TPVHL.

The sensitivity of TPVHL to variations in the discount rate

Table 5 portrays the impact of using 5% and 10% discount rates on the total and average present value of human life losses associated with COVID-19 in Japan.

Table 5: The present value of human life losses from COVID-19 in Japan – assuming 5% and 10% discount rates (in 2020 Int$)

Age group in years	Present value of human life lost at 5% discount rate (Int$)	Present value of human life lost at 10% discount rate (Int$)
0-9	-	-
10-19	-	-
20-29	1,592,322	836,430
30-39	4,615,563	2,497,315
40-49	12,332,524	6,987,714
50-59	33,357,457	20,278,305
60-69	82,822,082	55,868,835
70-79	140,416,124	109,796,029
80 & above	162,720,311	142,474,033
TOTAL	**437,856,383**	**338,738,661**
Present value per human life	**253,096**	**195,803**

Recalculation of the model with a 5% discount rate, holding all the other parameters constant, resulted in an Int$58,606,915 (11.8%) reduction in TPVHL, and a fall of Int$33,877 per human life. Instead, the application of a discount rate of 10%, all other parameters held constant, diminished the TPVHL by Int$157,724,638 (31.8%), and a reduction of Int$91,170 per human life.

The sensitivity of TPVHL to variations in mean life expectancy holding discount rate contact at 3%

Table 6 depicts the effects of reanalysing the human capital model with the average global and the world highest life expectancies while holding all other parameters constant.

Table 6: The present value of human life losses from COVID-19 in Japan – assuming mean global and world's highest life expectancies (in 2020 Int$)

Age group in years	Present value of human life lost at 3% discount rate and mean global life expectancy of 73.2 years (Int$)	Present value of human life lost at 3% discount rate and the world highest life expectancy of 88.17 years (Int$)
0-9	0	0
10-19	0	0
20-29	2119712.619	2,374,730
30-39	5,660,914	6,689,079
40-49	13,380,588	17,295,597
50-59	29,422,676	45,207,009
60-69	45,345,808	109,400,215
70-79	0	190,954,938
80 & above	0	263,830,154

TOTAL	**95,929,699**	**635,751,722**
Present value per human life	**55,451**	**367,487**

Reanalysis of the human capital model with the global average life expectancy at birth, holding all other parameters constant, reduced the TPVHL by Int$400,533,599 (80.7%), and the average net present value per human life by Int$231,522. On the other hand, re-estimation of the model with the world highest life expectancy at birth, holding all other parameters constant, increased the TPVHL by Int$139,288,423 (28%), and the average per human life by Int$80,514.

IV. DISCUSSION

Key findings

- The 1,730 human life losses associated with COVID-19 had a TPVHL of Int$496,463,298.
- The present value per human life was Int$286,973.
- Recalculation of the model with 5% and 10% discount rates, holding all the other parameters constant, reduced the TPVHL by 11.8% and 31.8%, respectively.
- Reanalysis of the model with the global average life expectancy at birth reduced the TPVHL by 80.7%; while the use of the world highest life expectancy at birth increased the TPVHL by 28%.

The TPVHL is equivalent to 0.009% of Japan's total GDP in 2020. Whereas, the present value per human life was 7-fold the GDP per person. There is a negative relationship between the discount rate used and the TPVHL. However, there is a positive relationship between the magnitude of life expectancy used in the analysis and the TPVHL.

Comparison with other similar studies

Japan's present value per human life of Int$286,973 was lower than those of Spain [21], Italy [19], China [16], France [17], Mauritius [20], and USA [24] of Int$470,798, Int$369,088, Int$356,203, Int$339,381, Int$312,069, and Int$292,889 by 64.1%, 28.6%, 24.1%, 18.3%, 8.7%, and 2.1%. There is a greater proportion of people in Japan living beyond the age of 60 years than the other six countries, and of course with lower numbers of YLL.

However, the average value per human life for Japan was higher than Int$231,217 in Canada [15], Int$228,514 in Turkey [22], Int$225,104 in the UK [23], Int$165,187 in Iran [18], Int$99,629 in Brazil [14] and Int$87,442 in Africa [13] by 19.4%, 20.4%, 21.6%, 42.4%, 65.3%, and 69.5%.

The Implications for the Government of Japan

The large value per human life loss associated with COVID-19 imply the need for increased investment health-related systems to bridge the persisting gaps in the coverage of essential health services [6,9], safeguards against the risk of catastrophic health expenditures [7], safely managed drinking water and sanitation [7], and the IHR [5]. The current health expenditure (CHE) per capita in Japan of Int$4,563 was greater than those of the UK and Italy of Int$4,338 and Int$3,620 by 5% and 21%, respectively. However, the CHE per capita in Japan was respectively lower than those of the USA of Int$10,246, Germany of Int$5,923, France of Int$5,011, and Canada of Int$4,929 by 125%, 30%, 10%, and 8% [10].

McIntyre, Meheus and Røttingen [37] recommends a "*...relative target of government expenditure on health, funded from domestically mobilised resources, of at least 5% of GDP"* (p.135) to ensure that "*...OOP payments are not to exceed 20% of the total amount spent on health care*" (p.129). In 2017, Japan's domestic general government expenditure on health as a percentage of GDP was 9.22%, and OOP payment was 12.85% of CHE [10]. In spite of the fact that Japan exceeds the 5% minimum threshold, there is still a need to advocate for increased government expenditures to bridge the extant gaps in the effective coverage of essential health-related services.

Study limitations

There are some limitations to this study. First, the HCA does not take into account views of persons at risk of COVID-19 infection and death; and also assumes the only purpose of prevention and control of COVID-19 is to boost GDP of a country [11,12]. Of course, prevention and control of the pandemic also serve other purposes, such as assuring the right to health [38], right to medical care (Article 25) [39], and right to life (Article 3) [39].

Second, the GDP calculations ignore income and wealth inequalities, non-marketed contributions to society, quality of life, depletion of natural resources, and pollution of the environment (including climate change) [40].

Third, any potential years of life lost above the national life expectancy of 85 years are valued at zero. It could be argued that it may reinforce age-based discrimination in the allocation of scarce resources for combatting COVID-19 [41]. According to the WHO [41] world report on ageing and health, older persons make contributions "*by direct participation in the formal or informal workforce, through taxes and consumption, through transfers of cash and property to younger generations and through a myriad of less tangible benefits that accrue to their families and communities*" (p.16). In the current study, a sensitivity analysis was conducted to gauge the impact of variation in assumed life expectancy on the TPVHL.

V. CONCLUSION

Every human life loss associated with COVID-19 has a substantial discounted monetary value of Int$286,973, which was 7-fold the GDP per person. This evidence would be useful to the Ministry of Health, Labour and Wealth when advocating for increased investments into health-related systems to bridge the narrow gaps in UHC, IHR, and water and sanitation coverage. Of course, there are other justifications for assuring universal population coverage of essential health services, and water and sanitation services, such as the human rights to medical care, life, and enjoyment of leisure [38,39]. The service gaps also relate to the United Nations Development Goals 3 on healthy lives for all and Goal 6 on water and sanitation for all [42].

In order to ensure rational decision-making, the evidence presented in this paper, ought to be complemented with a cost-benefit analysis of COVID-19 preventive interventions (including physical distancing, handwashing, disinfecting of hands and surfaces, health education); diagnosis options; settings for quarantine; contact tracing options; options for the care of those at various COVID-19 clinical stages (asymptomatic, pre-symptomatic, mild, moderate, severe); rehabilitative care options; mental health care options for health workers, patients, and families; and alternative ways of disposing of bodies of those who die from COVID [13-24].

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CONFLICT OF INTEREST

None of us has any actual or potential conflict of interest.

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