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Research note

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The net present value of human lives lost due to coronavirus disease (COVID-19) in the Islamic Republic of Iran

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Abstract

Objective: As of 11 April 2020, there were 68,192 confirmed cases, including 4,232 deaths. This study aimed to estimate the net present value of human lives lost due to COVID-19 in Iran as of 11 April 2020.

Results: The 4,232 human lives lost had a total net present value of Int\$ 436,275,007. The average net present value per human life was Int\$103,090. Re-estimation of the economic model with 5% and 10% discount rates resulted in a reduction in the expected total net present value by Int\$ 64,881,144 (14.9%) and Int\$ 168,066,782 (38.5 %), respectively. Additional re-calculation of the economic model using the highest life expectancy in the world (i.e., that of the Japanese Females) increased the total net present value of human lives lost by 114%.

Keywords: Coronavirus disease; net present value of human lives; non-health gross domestic product

Introduction

The Islamic Republic of Iran, an upper-middle-income economy, is one of the 21 Member States of the WHO Eastern Mediterranean Region (EMR) [1]. The country has a population of 84.1 million persons, a gross domestic product (GDP) of Int\$ 1,500.5 billion, and a per capita GDP (PCGDP) of Int\$ 17,832 [2].

As of 11 April 2020, globally, there were 1,610,909 confirmed cases of COVID-19; and 99,690 deaths. The EMR had 92,226 confirmed COVID-19 cases and 4,771 deaths. Iran borne 68,192 (74.7%) of confirmed cases and 4,232 (89.2%) deaths in the EMR [3].

Why has Iran borne a disproportionate share of COVID-19 cases and deaths? It could be due to gaps in the Universal Health Coverage (UHC), International Health Regulations (IHR), and coverage of water and sanitation. UHC, which means Iranians receive the essential health services they need without suffering financial hardship, can be viewed as a proxy indicator of the strength and resilience of the underlying national health system [4]. Iran has a UHC service coverage index of 65%, implying a 35% gap in the coverage of reproductive, maternal, new-born and child health, infectious diseases (such as COVID-19); non-communicable diseases; and service capacity and access. About 3.8% of the population spent above 25% of their income on health care.

The IHR capacities are a proxy of the vibrancy of the national disease surveillance system [5]. In 2018 IHR capacities of chemical events, laboratory, health service provision, national health emergency framework, and legislation and financing had a rating of 100% [6]. The IHR coordination and national IHR focal point functions, food safety, surveillance, human resources, risk communication, and radiation emergencies had a rating of 80%, implying a 20% gap. While the points of entry, the zoonotic events, and the human-animal interface IHR capacities had a rating of 60%, implying a gap of 40%. The average of 13 IHR core capacity scores was 85%, implying an overall gap of 15% [7].

The coverage of basic water and sanitation services are proxy indicators for the performance of systems that tackle social determinants of health. In 2017, 88% of the Iranian population was using at least basic sanitation services, implying that 12% were not [8]. In the same year, 92% of the population were using safely managed drinking-water services, implying that 8% were not [9].

Iran's current health expenditure per capita of US\$475.5 in 2017 [10], although within the range of US\$ 297 (minimum) to US\$984 (maximum), it was lower than the upper-middle-income countries recommended population-weighted mean of US\$536 per person [11].

Thus, there is a need for evidence on the net present value of human lives for use in advocating for increased investments in expanding coverage of essential health services, water and sanitation, and IHR capacities. To the best of our knowledge, no study has estimated the net present value of human lives lost from COVID-19 in Iran. This study aimed to estimate the net present value of human lives lost due to COVID-19 in Iran as of 11 April 2020.

Main text

Methods

Estimating the net present value of human lives lost

The current study used the human capital approach (HCA) pioneered Petty [13] in the 16th Century and further refined by Farr [14] in the 18th Century. Fein [15], Mushkin and Collings [16], Landefeld

and Seskin [17], Linnerooth [18], and Weisbrod [19] provides the theoretical foundations for applications of HCA to value human life.

According to Weisbrod [19], “..the value of a person to others is measured by any excess of his contribution to production over what he consumes from production...The present value of a man at any given age may be defined operationally as his discounted expected future earnings stream (net of his consumption)” (pp.426-427). Also, the WHO guide to identifying the economic consequences of disease advises that the expenditures on health should be removed GDP in the valuation of a human life lost [20]. This study followed the counsel of Weisbrod [19] and WHO [20] to estimate the net present value of human lives lost (NPVHL) due to COVID-19 in Iran.

The formulas developed and applied in a recent study on the fiscal value of human lives lost due to COVID-19 deaths in China [21] were adapted and used to estimate the total NPVHL from COVID-19 in Iran ($NPVHL_{IRAN}$). The only difference was that while the China study assessed value of human lives lost for three age groups (24-49 years, 50-64 years, and 65 years and above), the Iran study appraised the NPVHL for nine age groups, including the 0-9-year-old ($NPVHL_{0-9}$), 10-19-year-old ($NPVHL_{10-19}$), 20-29-year-old ($NPVHL_{20-29}$), 30-39-year-old ($NPVHL_{30-39}$), 40-49-year-old ($NPVHL_{40-49}$), 50-59-year-old ($NPVHL_{50-59}$), 60-69-year old ($NPVHL_{60-69}$), 70-79-year-old ($NPVHL_{70-79}$), and 80-year-old and above ($NPVHL_{\geq 80}$). The $NPVHL_{IRAN}$ due to COVID-19 in Iran was derived using the following equations [21]:

$$NPVHL_{IRAN} = \left(NPVHL_{0-9} + NPVHL_{10-19} + NPVHL_{20-29} + NPVHL_{30-39} + NPVHL_{40-49} + NPVHL_{50-59} + NPVHL_{60-69} + NPVHL_{70-79} + NPVHL_{\geq 80} \right) \quad (1)$$

$$NPVHL_j = \sum_{t=1}^{t=n} \left\{ \frac{1}{(1+r)^t} \right\} \times [NGDPPC_{Int\$}] \times [COVID_j] = \left\{ \frac{1}{(1+r)^1} \right\} \times [NGDPPC_{Int\$}] \times [COVID_j] + \left\{ \frac{1}{(1+r)^2} \right\} \times [NGDPPC_{Int\$}] \times [COVID_j] + \dots + \left\{ \frac{1}{(1+r)^n} \right\} \times [NGDPPC_{Int\$}] \times [COVID_j] \dots \dots \dots (2)$$

Where: $1/(1+r)^t$ is the discount factor; r is the discount rate; $\sum_{t=1}^{t=n}$ is the total from year $t = 1$ to $t = n$; $t = 1$ is the first year of life lost to COVID-19 and n is the last year of life of lost to COVID-19 within an age group; $NGDPPC_{Int\$}$ is net GDP per person in International Dollars (Int\$), obtained by subtracting current health expenditure per person (CHEPP) from per capita GDP (PCGDP); $COVID_j$ is the number of human lives lost from COVID-19 in the j^{th} age group. The base year was 2020. The detailed model and illustration of how to estimate the equations can be found in Kirigia and Muthuri [21].

Data and data sources

The data and sources are contained in Table 1.

Table 1: Data and data sources		
Variable	Data value	Source

Number of COVID-19 deaths for Iran as of 11 April 2020.	4,232	WHO COVID-19 situation report 82 [3]
Distribution of COVID-19 deaths by age group	0-9 years = 0; 10-19 years = 0.0009775; 20-29 years = 0.0068426; 30-39 years = 0.0175953; 40-49 years = 0.0371457; 50-59 years = 0.1270772; 60-69 years = 0.3020528; 70-79 years = 0.3049853; and 80 years and above = 0.2033236	Verity <i>et al.</i> [12]
Iran's life expectancy at birth in years	75.7 years	WHO World Health Statistics 2019 [7]
Global average life expectancy in years	72 years	WHO World Health Statistics 2019 [7]
World's highest life expectancy in years	87.1 years	WHO World Health Statistics 2019 [7]
Iran's per capita GDP (PCGDP)	Int\$ 17,832	IMF World Economic Outlook database [2]
Current health expenditure per person in Iran (CHEPP)	Int\$ 1,748	WHO Global Health Expenditure Database [10]
Net GDP per capita (NGDPPC)	NHGDPPC= PCGDP – NHGDPPC = Int\$ 17,832 – Int\$1,748 = Int\$ 16,084	Authors calculation.

Results

Table 2 shows the distribution of the net present value of human lives lost from COVID-19 by age group.

Table 2: Net present value of human lives lost due to COVID-19 in Iran (in 2020 Int\$) – at three discount rates			
Age group in years	Net present value of human lives lost at 3% discount rate (Int\$)	Net present value of human lives lost at 5% discount rate (Int\$)	Net present value of human lives lost at 10% discount rate (Int\$)
0-9	0	0	0
10-19	1,852,417	1,262,893	663,385
20-29	12,087,042	8,541,561	4,621,530
30-39	28,040,292	20,712,918	11,736,117
40-49	50,569,305	39,425,035	23,966,842
50-59	133,337,298	110,900,758	74,809,713

60-69	190,233,715	170,779,664	133,538,288
70-79	20,154,938	19,771,034	18,872,351
>=80	0	0	0
Total	436,275,007	371,393,863	268,208,225
Average net present value per human life lost	103,090	87,758	63,376

The 4,232 human lives lost had a total net present value of Int\$ 436,275,007 (0.03% of Iran's total GDP), i.e., assuming a discount rate of 3% and Iran's average life expectancy at birth of 75.7 years. Of which, 0.4% was borne by the 10-19-year-olds; 2.8% by 20-29-year-olds; 6.4% by 30-39-year-olds; 11.6% by 40-49-year-olds; 30.6% by 50-59-year-olds; 43.6% by 60-69-year-olds; and 4.6% by 70-79-year-olds.

The average net present value per human life was Int\$103,090. The average net present value per death decreased with an increase in age. For example, the net present value per death among 10-19-year-olds was Int\$447,784 compared to Int\$15,616 per death among 70-79-year-olds.

The economic model was re-estimated with 5% and 10% discount rates to gauge the impact on the total net present value of human lives lost to COVID-19. Use of those discount rates resulted in a reduction in the expected total net present value by Int\$ 64,881,144 (14.9%) and Int\$ 168,066,782 (38.5 %), respectively. The corresponding decreases in average net present value per human life lost due to COVID-19 were Int\$ 15,331 and Int\$ 39,713.

Table 3 compares the net present value of human lives lost from COVID-19 in Iran, assuming Iran's, global, and world's highest life expectancies.

Table 3: A comparison of net present value of human lives lost from COVID-19 in Iran: assuming Iran's, global and world's highest life expectancies (in 2020 Int\$ or PPP)			
Age group in years	Net present value of human lives lost at 3% discount rate and assuming the Iran's average life expectancy of 75.7 years (Int\$)	Net present value of human lives lost at 3% discount rate and assuming the global average life expectancy of 72 years (Int\$)	Net present value of human lives lost at 3% discount rate and assuming world's highest life expectancy of 87.1 years (Int\$)
0-9	0	0	0
10-19	1,852,417	1,830,159	1,961,559
20-29	12,087,042	11,768,220	13,113,784
30-39	28,040,292	26,938,511	31,588,493
40-49	50,569,305	47,443,379	60,636,107
50-59	133,337,298	118,965,514	179,620,515
60-69	190,233,715	144,324,692	338,080,167

70-79	20,154,938	-	220,777,268
>=80	0	-	86,225,396
Total	436,275,007	351,270,475	932,003,289
Average net present value per human life lost	103,090	83,003	220,228

Re-appraisal of the economic model, assuming the lower global average life expectancy at birth of 72 years, resulted in a total net present value of Int\$351,270,475 and an average net present value of Int\$83,003 per death. Thus, the use of a lower average life expectancy reduced the total net present value by Int\$83,003 (19%).

Re-analysis of the economic model using the highest life expectancy in the world (i.e., that of the Japanese Females) increased the total net present value to Int\$932,003,289 and the average net present value of Int\$220,228. Therefore, the use of the highest average life expectancy in the world increased the total net present value by Int\$ 495,728,282 (114%).

Limitations

Our study had some limitations. First, according to the WHO World Health Statistics Report 2019, the completeness of cause-of-death data was 65% in 2017 [7]. The cause-of-death for about 35% of deaths is not recorded. Therefore, the number of notified COVID-19 cases and deaths are likely to be an underestimate. Should that be the case, the total net present value of human lives lost reported in this paper would also be an underestimate.

Second, our study omits the COVID-19 health system costs related to prevention (water, soap, sanitizers, personal protective equipment), testing (diagnosis), case tracing, quarantine, and hospitalization of severe cases, and post-mortem. We also did not take into account funeral-related costs, including the purchase of caskets, hiring of a hearse, transport of the bodies (and family and friends), funeral ceremonies, and time of family and friends preparing and attending the funerals [21].

Third, given the limited scope, this study did not take into account the macroeconomic impact of COVID-19 pandemic on agriculture, education, financial services (e.g., banking and stock exchange), hydrocarbon (oil and gas), international trade and commerce, tourism and travel, and manufacturing sectors [23].

Finally, when strictly applied, the human capital approach employed in the current study would value the contributions of housewives, the elderly, the handicapped (physically and mentally), and children at zero [23]. To avoid human rights and ethical issues, we valued all the years of life lost, irrespective of age, gender, and economic status, using the same numeraire, i.e., net GDP per capita.

Abbreviations

CHEPP: current health expenditure per person

COVID-19: Coronavirus disease

COVID_j: Number of COVID-19 deaths in jth age group

DSS: Disease surveillance system

EMR: Eastern Mediterranean Region

GDP: Gross domestic product

HCA: Human capital approach

IHR: International health regulations

IMF: International Monetary Fund

Int\$: International Dollars or Purchasing Power Parity (PPP)

NVHL: Net present value of human lives lost

NPVHL_{IRAN}= Net present value of human lives lost in Iran due to COVID-19 deaths

NPVHL₀₋₉: Net present value of potential years of life lost among those aged 0-9 years

NPVHL₁₀₋₁₉: Net present value of potential years of life lost among those aged 10-19 years

NPVHL₂₀₋₂₉: Net present value of potential years of life lost among those aged 20-29 years

NPVHL₃₀₋₃₉: Net present value of potential years of life lost among those aged 30-39 years

NPVHL₄₀₋₄₉: Net present value of potential years of life lost among those aged 40-49 years

NPVHL₅₀₋₅₉: Net present value of potential years of life lost among those aged 50-59 years

NPVHL₆₀₋₆₉: Net present value of potential years of life lost among those aged 60-69 years

MVHL₇₀₋₇₉: Net present value of potential years of life lost among those aged 70-79 years

NPVHL_{=>80}: Net present value of potential years of life lost among those aged 80 years and above

NGDPPC_{Int\$}: Non-health GDP per person in purchasing power parity

NHS: National health system

PCGDP: Per capita GDP

r: Discount rate

SDH: Social determinants of health

UHC: Universal health coverage

US\$: United States Dollar

WHO: World Health Organization

Declarations

Ethics approval and consent to participate

Not applicable. No ethical clearance was required because the study relied completely on analysis of secondary data available in public sources.

Consent for publication

Not applicable.

Availability of data and materials

All data generated or analysed during this study are included in this published article.

Competing interests

The authors declare that they have no competing interests.

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Authors' Contributions

JMK, RDKM and NGM designed the study; extracted the data from various databases and reports; designed the economic model on Excel software; reviewed literature; and drafted the manuscript. Both authors approved the final version of the paper.

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