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Non-Health Gross Domestic Product (NHGDP) Loss Due To Covid-19 Deaths in West Bengal, India

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Non-Health Gross Domestic Product (NHGDP) Loss due to COVID-19 Deaths in West Bengal, India

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ABSTRACT

Objectives: The state of West Bengal witnessed significant surge of COVID-19 in all three waves. However, there is a gap in understanding the economic loss associated with COVID-19. This study estimates future NHGDP losses associated with COVID-19 deaths in West Bengal, India.

Setting: Various open domains were used to gather data on COVID-19 deaths in West Bengal and the aforementioned estimates.

Primary and secondary outcome measures: The NHGDP losses were evaluated using cost-of-illness approach. Future NHGDP losses were discounted at 3%. Excess death estimates by the World Health Organisation (WHO) and Global Burden of Disease (GBD) were used. Sensitivity analysis was carried out by varying discount rates and Average Age of Death (AAD).

Results: 19,864 deaths in West Bengal since 17th March 2020 till 7th January 2022 decreased the future NHGDP by \$0.85 billion. Nearly 90% of loss was due to deaths occurring in above 30 years age-group. The majority of the loss was borne by the 46-60 years age-group. The NHGDP loss/death was \$42,646, however the average loss/death declined with rise in age. The loss increased to \$9.38 billion and \$9.42 billion respectively based on GBD and WHO excess death estimates. The loss increased to \$1.2 billion by considering lower age of the interval as AAD. At 5% and 10% discount rates the losses reduced to \$0.708 billion and \$0.507 billion respectively.

Conclusions: Results from the study suggest that COVID-19 contributed to major economic loss in West Bengal. The mortality and morbidity caused by COVID-19, the substantial economic costs at individual and population levels in West Bengal, and probably across India and other countries, is another argument for better infection control strategies across the globe to end the impact of this epidemic.

ARTICLE SUMMARY

Strengths and limitations of this study

- This study evaluates the NHGDP Losses associated with Covid-19 deaths in West Bengal.
- Open source data are used to compute the estimates.
- This study also evaluates the NHGDP losses after considering the excess death estimates given by GBD and WHO.
- Sensitivity analysis was carried out by varying discount rates and Average Age of Death (AAD).
- This study does not consider the costs associated with illness and recovery.

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- GDP per capita does not capture the inequality in the distribution of resources among people and households.

KEYWORDS

COVID-19, Economic Loss, Non-Health GDP, Excess Deaths, West Bengal, India

INTRODUCTION

With the COVID-19 pandemic, economies worldwide have faced several challenges in the form of the collapse of public health systems, employment, food availability and accessibility. The socioeconomic disruption caused by the pandemic is manifesting itself in the form of extreme poverty(1). The direct impact of the pandemic is in the form of a decline in domestic consumption, savings and investment. The indirect effects are on future business activity, a decline in tourism and business travel. There are spill-over effects on other sectors and economies through trade and production linkages and demand-side and supply-side disruptions. The effects on health are in the form of increased infections and mortality as well as shifts in healthcare spending(2). India witnessed difficult times with recurrent waves of infection creating new challenges for policymakers (1).

Until January 2022, India recorded 39,799,202 infections with 490,462 total deaths. In terms of infection, India is among the top 3 in the world after USA and France(3). Higher infection rates are found to be associated with an increased burden on healthcare systems(4). Estimation of mortality attributable to COVID-19 is important to understand the epidemiological and economic burden of the pandemic(5). The pandemic has created far-reaching consequences in the form of indirect effects due to morbidity. Social, economic and demographic variables play an important role in designing interventions, especially in Lower Middle-Income Countries (LMIC) like India where there exist wide differences across socioeconomic strata(6). Quantifying economic impact would have an important bearing on the policy decisions in West Bengal and similar regions in India which have witnessed significant health impacts across all three waves of the pandemic(7,8).

The economic impact of COVID-19 was more persistent in the states with lower GDP per capita with weaker healthcare infrastructure. It was also observed that governance played an important role in both health and economic outcomes(9). Patients with chronic conditions, particularly among poor, rural, and marginalized sections, experienced difficulties in accessing healthcare and were severely affected both socially and financially by the pandemic (10). A study based in Kerala found that majority of the burden was contributed by Years of Life Lost. Losses due to Years of Potential Productive Life Lost (YPPLL) were reduced as the infection was found to be lesser among the productive cohorts. The

Cost of Productivity Lost(CPL) for individuals aged 40–49 years old was found to be highest in the Kerala-based study (11).

In the health effects of the pandemic, it is well-known that not only the underlying mortality risk and diseases, but also socio-economic factors have been important in determining outcomes (including mortality from COVID-19). Hence, it is important to analyze the economic impact of non-health components of Gross Domestic Product (GDP), a dimension which has not been explored much in the Indian studies. This is because the point of interest is the indirect impact of mortality on non-health consumption expenditures since the use of health services or goods does not generate utility or welfare per se (12). It is further contended by Chisholm et al. (2010), “...the quantity of interest cannot be GDP, because medical care and health expenses actually form part of GDP; instead ... a more appropriate quantification of interest would be the impact of disease or injury on the non-health components of GDP”(13). This is consistent with the World Health Organisation (WHO) guidelines for quantifying the economic impact of a disease or an injury (14).

West Bengal is the sixth-largest state and the second-most densely populated state in India which contributes 8 percent of the country’s total population(15). It was one of the most affected states in all the three waves of COVID-19 infections(7,8). All these factors make West Bengal an important study area both geographically and demographically to examine the impact of COVID-19(15,16). This paper estimates the future NHGDP losses associated with COVID-19 deaths in West Bengal, India. The loss has been computed using both state-level available figures of associated deaths and the excess death figures reported by Global Burden of Disease (GBD) and the World Health Organisation (WHO).

METHODOLOGY

In this paper, a cost-of-illness model is used to estimate the NHGDP losses attributable to COVID-19 related deaths in West Bengal, India. GDP measures the monetary value of all final goods and services i.e. those that are bought by the final user and produced in a country in a given period. It takes account of all the output generated within the borders of a country. GDP includes some nonmarket production, such as defence or education services provided by the government (17).

The mechanisms through which deaths impact macroeconomic output include increased health expenditure, losses in labour and productivity and reduced investment in human and physical capital formation. The present study employs a macroeconomic societal outlook. The scope of this study is limited to economic losses (GDP), particularly the impact of COVID-19 deaths on non-health components of GDP in West Bengal state. Economic losses in terms of Non-Health Gross Domestic Product (NHGDP) among six age-group brackets viz. 0-15, 16-30, 31-45, 46-60, 61-75 and 75 and above

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were estimated to facilitate comparisons and to initiate advocacy for an increase in health investments against COVID-19.

$$NHGDP\ Loss = \sum_{i=1}^n D_i * DYLL_i * NHGDPPC \quad | \quad i = 1, 2, ..., n,$$

where 'i' represents 'n' age-gender cohorts; D_i = deaths at the given age and gender; $DYLL_i$ = Discounted Years of Life Lost; $NHGDPPC$ = Non-Health GDP Per Capita

$$DYLL_i = \frac{(1 - e^{-rYLL_i})}{r}$$

$NHGDPPC$ = $GDPPC - PCHE$

$GDPPC$ = GDP Per Capita

$PCHE$ = Per Capita Health Expenditure

r = Discount rate for the value of life (18).

$$YLL_i = LE - AAD$$

Where, YLL_i = Undiscounted Years of Life Lost

LE = Life Expectancy

AAD = Average Age at Death

The population data, COVID-19 deaths data (from 17th March 2020 till 7th January 2022), Life Expectancy data, per capita GDP (PCGDP) data and per capita health expenditure (PCHE) data of the state were gathered from openly available data sources (19–23). The study used midpoint age as the age of death for all the age brackets. Considering the legal minimum age for working i.e., 15 years (24). A sensitivity analysis was conducted to determine the effect of age on the overall total NHGDP loss estimate. The model was re-estimated assuming an average age at death to be the starting age of each age-group bracket. Based on existing literature discounted rate of interest to measure the value of life is taken as 2.9% (18). As a sensitivity analysis NHGDP loss has also been computed using 5% and 10% of discounted rates of interest.

Details on the input parameters used in the study are described in Table-I.

Table I: Input parameters for the study

Parameters	Values	Reference	Till Date
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Number of cases	1711957	(20)	7 th Jan-2022
Number of deaths	19864	(20)	7 th Jan-2022
Discount rate for value of life	2.90%	(18)	NA
Life Expectancy at Birth in West Bengal		(19)	NA
Male	71 Years		
Female	73 Years		
Per capita Gross Domestic Product (GDP) in West Bengal	121267 INR/year	(22)	NA
Per capita health expenditure in West Bengal	1643 INR/year	(23)	NA
Excess Death Estimates GBD in West Bengal	220000 deaths	(25)	31 st Dec-2021
Excess Death Estimates WHO in West Bengal	220900 deaths	(26)	20 th May-2021

Validation

The data on COVID-19 were compiled from official bulletins, reports and newspaper articles (20,25–29), while data on life expectancy, per capita GDP and per capita health expenditures were collected from central and state government published reports (19,22,23). The NHGDP losses were computed based on the works by Kirigia et al. (30,31). The value of life was discounted based on the study carried out by Shanmugam (18).

Patient and public involvement

The analysis employed in the study used secondary data and did not involve the public and/or patients directly in any of the phases including plan, design or reporting.

RESULTS

In West Bengal, due to COVID-19, the NHGDP loss amounts to ₹17.98 billion and \$0.85 billion respectively. Approximately 60% of NHGDP loss is borne by deaths among males, while the rest is attributable to deaths among females. This trend is similar to that observed in the deaths, with more deaths being observed among the males. This gap however reduces approximates to 4% (52% and 48% among males and females respectively) in the 61-75 age-group. The major proportion of the loss is found to be borne by the middle age-group of 46-60 years. People aged more than 75 years were excluded from the analysis as YLL fell to zero as the LE of West Bengal is 72 years. NHGDP loss associated with each death is \$42,646. Figure 1 shows the age-wise continuous decline in NHGDP

loss/death on one side and the increasing percentage of NHGDP loss till the 46-60 years age group that falls steeply thereafter in the 61-75 years age-group.

The NHGDP losses were also estimated using the excess death measures provided by GBD and WHO(25,27–29). In these analyses, the calculation is based on the assumption that the death proportions remain similar across age and gender to those reported at the state level. The loss estimates amount to \$9.38 billion and \$9.42 billion respectively based on the GBD and WHO estimates.

Table II NHGDP Loss in West Bengal

Age	NHGDP Loss (\$)			NHGDP Loss/Death
	Male	Female	Total	
0-15	5915504	3427051	9361023	157085
16-30	28310534	21380100	49765538	147371
31-45	124756932	62792897	188723009	121805
46-60	254158309	164853239	423439776	82305
61-75	85296501	78527626	175838559	21279
Total	498437780	330980912	847127905	42646

< Insert Figure 1 >

Sensitivity Analysis

The re-estimation conducted as a part of sensitivity analysis assumed average age at death to be the starting age of each age group range. Table III shows that, the NHGDP loss increases to \$1.2 billion.

Table III: Sensitivity Analysis I

Age	NHGDP Loss (\$)		
	Male	Female	Total
0-15	6199379	3580124	9794361
16-30	30031160	22583855	52676158
31-45	139047690	69350054	209355385
46-60	322286041	203384595	529285303
61-75	257699093	170986439	438492651
Total	755263363	469885066	1239603857

Based on existing literature, discounted rate of interest to measure the value of life is taken as 2.9 percent (18). NHGDP loss computed using 5 and 10 percent as discounted rate of interest showed (Table III) that the loss declines to \$0.708 billion and further to \$ 0.507 billion respectively.

Table IV: Sensitivity Analysis II

NHGDP Loss (r=0.05) in \$			NHGDP Loss (r=0.10) in \$		
Male	Female	Total	Male	Female	Total
4013437	2307523	6326745	2128747	1217245	3346356
19869666	14870818	34768984	10836101	8045745	18884662
94913289	47194430	142699108	56570689	27697796	84383942
215111087	137332211	355533133	151284365	93926954	246516190
82702961	74640064	168792779	76943029	66384902	153494309
416610440	276345046	708120748	297762930	197272642	506625458

DISCUSSION

Key findings of this study

The findings of this study reflect that the NHGDP Loss in West Bengal is substantially high at \$0.85 billion. The majority of the NHGDP loss is found to be borne by males (60%). Further, the highest percentage of the loss is attributable to the 46-60 age-group. These estimates are based on the state-level available data from government websites.

There has been an estimation of excess deaths across 74 countries including 31 low-and middle-income countries (LMIC). The estimated figures reflect a significantly higher number of deaths than reported(25). As per WHO projections also there could be over 4 million excess deaths in India (26,27,29,32). Both estimates are found to be more than ten times the reported figures for the state of West Bengal (25,26,33). Many of the published articles support these estimates, but the government of India has objected to the approach employed to compute the excess deaths due to the associated risk of bias (32). The generated estimates may involve some degree of bias; therefore the fact that there are excess deaths during the tenure needs to be seriously investigated. Given this, the estimates for NHGDP loss have been computed considering the excess deaths to be ten times the actual numbers. The loss estimates amount to \$9.38 billion and \$9.42 billion respectively based on the GBD and WHO estimates.

In the analysis, the NHGDP loss computed using Average age of death (AAD) is found to vary with the age of death. To take account of this factor, a sensitivity analysis was carried out by considering the lower age of the interval as the average age of death. The NHGDP loss was thus found to increase from \$ 0.847 billion to \$1.2 billion.

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The NHGDP loss also varies depending on the discounting rate. Initial calculations considered a discount rate of 2.9% (18). This was changed to 5% and 10% for sensitivity analysis. The NHGDP loss declined to \$0.708 billion and \$0.507 billion respectively.

As discussed, there is a paucity of literature which accounts for the NHGDP loss associated with COVID-19 deaths. While similar studies have been conducted in other countries(31,34), there is only one study based in India which looks into the NHGDP loss but this study considered data only till August 12th, 2020 (35). The discount rates used in the paper are different from what has been used in this study. Further, it does not consider the loss of male and females separately as it is done at the all India level and such segregation is not available at the all India level. Moreover, two major peaks of Covid-19, one in September 2020 and another in April 2021 which had been most devastating in terms of life loss have not been considered in the mentioned study (36). The present study is much more comprehensive as it also considers the sensitivity analysis and the excess deaths predicted by GBD and WHO (25,27–29). The huge losses in one single state in India give us an idea about the overall loss incurred in the country. The findings of this study are corroborated by the findings of a Chinese study which demonstrates the effect of COVID-19 beyond the healthcare system and identifies that the potential productivity losses caused by a pandemic may by far exceed the healthcare cost(34). The NHGDP loss thus justifies the redirection of resources from other sectors of the economy to strengthen healthcare systems(34). Other studies have also identified the extent of the impact of COVID-19 on the world economy and its importance to institute future policies to protect society(37,38).

What is already known on this topic

The COVID-19 pandemic has impacted the economies worldwide by disrupting the socio-economic fabric of the societies (1). It has manifested in terms of increased risk of extreme poverty and under-nourishment levels (1). The pandemic has far-fetched consequences in terms of its indirect effects due to morbidity and mortality(2). Economic burden associated with COVID-19 has been estimated across various countries around the globe. There are studies based on Africa(39), China(34), India(11), Iran(40), Russia(41), Spain(42), Switzerland(43), United States(44) and Vienna(45). As per the US estimates GDP loss associated with COVID-19 would amount to a cumulative US\$1.4 trillion by 2030. In China, the estimated health-care and societal costs associated with COVID-19 amounted to 4.26 billion Chinese yuan(34). Economic burden associated with inpatient cases of COVID-19 alone amounted to \$1.4 billion in Iran (40). The socio-economic burden of COVID-19 in the Russian Federation amounted to approximately \$71.1 billion i.e. 4 % of their GDP (41). The existing studies indicate the huge economic burden imposed by the pandemic.

Fiscal value or NHGDP loss has been estimated by very few countries. The fiscal value or NHGDP loss in China amounts to Int\$ 924 million(34) while that in India amounts to Int\$ 815 million(35).

What this study adds

This study adds to the existing limited literature on NHGDP loss attributable to COVID-19. This study substantiates the existing study based on West Bengal state in India since it takes into consideration two most devastating peaks (in terms of life loss) of Covid-19, one in September 2020 and another in April 2021 which had not been considered in the previous study (35). The discount rates used in the present paper are different from what has been used in the previous study conducted in India (35). Further, the previous study based in India did not consider the attributable losses separately for males and females; a dimension addressed by this study (35). This study has also conducted sensitivity analysis by varying the AAD and considering the impact of excess deaths predicted by GBD and WHO.

LIMITATIONS

This study does not consider the costs associated with illness and recovery i.e. absence from work and costs associated with the treatment. GDP per capita does not capture the inequality in the distribution of resources among people and households. It implies that the average income per capita might remain unchanged but the distribution of income might change, which has considerable implications at the household level(17). Further, GDP only captures economic activities associated with market transactions, and does not take into consideration the valuation of domestic activities(17). For example, the value of labour of a woman who chooses to stay at home to conduct household chores and raise children is not accounted for (17). GDP also does not account for the cost of production and consumption externalities such as pollution, climate change and the cost of consuming abusive substances (like smoking and alcohol) (17). This paper also does not account for the psychological pain associated with the death of one's near and dear ones.

CONCLUSION

This paper tried to contribute to the literature on the economic burden of COVID-19 deaths in West Bengal. The NHGDP loss (computed using state-level reported death figures) accounts for 0.2% of the State Domestic Product (SDP) of West Bengal. If the excess deaths reported by WHO and GBD are considered then the NHGDP loss is found to be equivalent to 1.8% of the SDP of West Bengal. The loss is found to vary with the AAD and the discounting rate of interest. The NHGDP loss is significant especially for a state like West Bengal where a fifth of the population lives below the poverty line(38). The evidence from this paper substantiates the argument for the requirement of improved health infrastructure and greater allocation of funds to address the basic public health demands. The findings

of this study re-establishes that health and the economy are inseparably interlinked, probing the health and financial sectors of the economies to re-consider the laid down priorities to ensure sustainable improvements in population health, preparedness and economic performance.

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Contribution statement:

The conception and design of the study, or acquisition of data, or analysis and interpretation of data – PB, DJ, NM, MSN. Drafting the article or revising it critically for important intellectual content –DJ, PB, NM. Final approval of the version to be submitted – JM, AB, DJ, NM, MSN.

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Data sharing statement:

All data that is incorporated into the article is available from the references mentioned. Raw data has been uploaded in the following link: <https://doi.org/10.5061/dryad.573n5tbc4>

Ethical statement: The study has been conducted using publicly available data. No ethical approvals were sort for this study.

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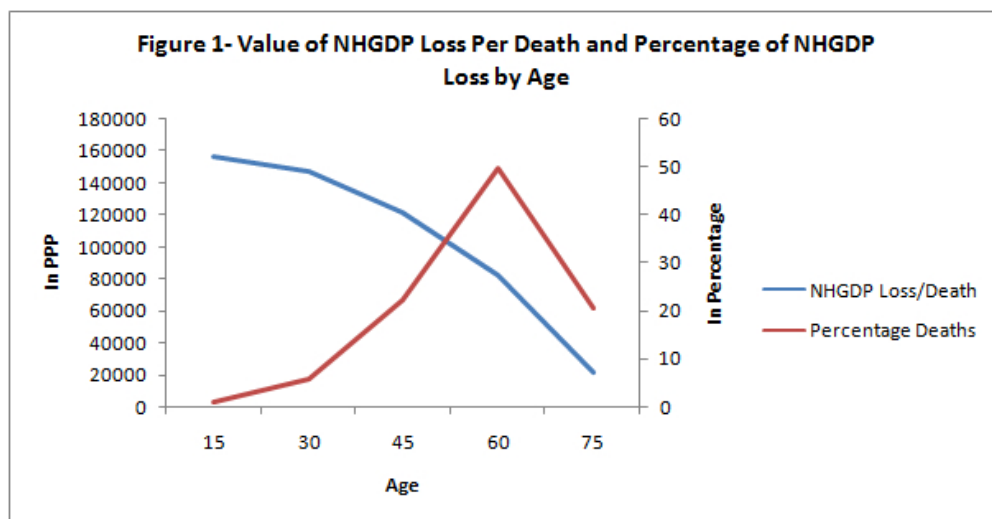
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Value of NHGDP Loss per Death and Percentage of NHGDP Loss by Age

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- GDP per capita does not capture the inequality in the distribution of resources among people and households.

KEYWORDS

COVID-19, Economic Loss, Non-Health GDP, Excess Deaths, West Bengal, India

INTRODUCTION

With the COVID-19 pandemic, economies worldwide have faced several challenges in the form of the collapse of public health systems, employment, food availability and accessibility. The socioeconomic disruption caused by the pandemic is manifesting itself in the form of extreme poverty(1).The direct impact of the pandemic has been observed across various forms such as decline in domestic consumption, savings, and investment. The indirect effects are on future business activity, and decline in tourism and business travel. Additional effects include spill-over effects on other sectors and economies through trade and production linkages and demand-side and supply-side disruptions. The effects on health are in the form of increased infections and mortality as well as shifts in healthcare spending(2).

India witnessed difficult times with recurrent waves of infection creating new challenges for policymakers (1). Till January 2022, India recorded 39,799,202 infections with 490,462 total deaths. In terms of infection, India is among the top 3 in the world after USA and France(3). Higher infection rates are associated with an increased burden on healthcare systems(4).The pandemic has created far-reaching consequences in the form of indirect effects due to morbidity and mortality (5). Social, economic and demographic variables play an important role in designing interventions, especially in low- and middle-income countries (LMICs) such as India where there exist wide differences across socioeconomic strata(5). Quantifying the economic impact would have an important bearing on the policy decisions in similar regions in India and other developing countries which have witnessed significant health impacts across all three waves of the pandemic(6,7).

Governance was observed to play an important role in both health and economic outcomes in managing COVID-19(8). In India, the economic impact of COVID-19 was more persistent in the states with lower GDP per capita and with weaker healthcare infrastructure(9). Patients with chronic conditions, particularly among poor, rural, and marginalized sections, experienced difficulties in accessing healthcare and were severely affected both socially and financially by the pandemic (9). Study based in Kerala found that majority of the burden was contributed by Years of Life Lost (YLL), and losses due to Years of Potential Productive Life Lost (YPPLL) were reduced due to the incidence of

COVID infection. Cost of Productivity Lost(CPL) for individuals aged 40–49 years old was found to be highest in the Kerala-based study (10).

With regards to the health effects of the pandemic, it is well-known that not only the underlying mortality risk and diseases, but also socio-economic factors are important in determining outcomes (including mortality from COVID-19). This makes it important to analyse the economic impact of non-health components of Gross Domestic Product (GDP), a dimension which has not been explored much in studies from India. Measuring the economic impact of non-health components of GDP is the point of interest in our study is the indirect impact of mortality on non-health consumption expenditures, (11). It is further contended by Chisholm et al. (2010), “...the quantity of interest cannot be GDP, because medical care and health expenses actually form part of GDP; instead ... a more appropriate quantification of interest would be the impact of disease or injury on the non-health components of GDP”(12).The need to look at non-health components of GDP is consistent with the World Health Organisation (WHO) guidelines for quantifying the economic impact of a disease or an injury (13).

West Bengal is the sixth-largest state and the second-most densely populated state in India contributing to 8 percent of the country’s total population(14). The state was one of the most affected regions in the country across all the three waves of COVID-19 infections(6,7). All these factors make West Bengal an important study area, both geographically and demographically, to examine the impact of COVID-19(14,15). This paper estimates the future NHGDP losses associated with COVID-19 deaths in the state of West Bengal, India. The future NHGDP loss has been computed using state-level available figures of associated deaths, and the excess death figures reported by Global Burden of Disease (GBD) and the World Health Organisation (WHO).

METHODOLOGY

A cost-of-illness model was used to estimate the NHGDP losses attributable to COVID-19 related deaths in West Bengal, India. GDP measures the monetary value of all final goods and services i.e. those that are bought by the final user and produced in a country in a given period, and takes into account of all the outputs generated within the borders of a country. GDP includes non-market production, such as defence or education services provided by the government (16). The mechanisms through which deaths impact macroeconomic output include increased health expenditure, losses in labour and productivity and reduced investment in human and physical capital formation.

The present study employs a macroeconomic societal outlook, and the scope is limited to economic losses (GDP), in particular the impact of COVID-19 deaths on non-health components of GDP in the

state of West Bengal. Economic losses in terms of Non-Health Gross Domestic Product (NHGDP) were estimated among, six age-group brackets viz. 0-15, 16-30, 31-45, 46-60, and 61-75, and among males and females to facilitate comparisons. The formulas mentioned below were used for computation:

$$NHGDP\ Loss = \sum_{i=1}^n D_i * DYLL_i * NHGDPPC \quad | \quad i = 1, 2, \dots, n,$$

where 'i' represents 'n' age-gender cohorts; D_i = deaths at the given age and gender; $DYLL_i$ = Discounted Years of Life Lost; $NHGDPPC$ = Non-Health GDP Per Capita

$$DYLL_i = \frac{(1 - e^{-rYLL_i})}{r}$$

$NHGDPPC$ = $GDPPC$ - $PCHE$

$GDPPC$ = GDP Per Capita

$PCHE$ = Per Capita Health Expenditure

r = Discount rate for the value of life (17).

$YLL_i = LE - AAD$

Where, YLL_i = Undiscounted Years of Life Lost

LE = Life Expectancy

AAD = Average Age at Death

The population data, COVID-19 deaths data (from 17th March 2020 till 31 December 2022), life expectancy data, per capita GDP ($PCGDP$) data and per capita health expenditure ($PCHE$) data of the state were gathered from openly available data sources(18–22). The study used midpoint age as the age of death for all the age brackets, and considered the legal minimum age for working i.e., 15 years (23).

Scenario analysis was conducted to accommodate excess deaths estimates from WHO and GBD for effects on the overall total NHGDP loss estimate using similar proportion of deaths between age-groups, and males and females for India are similar to West Bengal.

Sensitivity analysis was conducted to determine the effect of age on the overall total NHGDP loss estimate. The model was re-estimated assuming an average age at death to be the starting age of each age-group bracket. Based on existing literature discounted rate of interest to measure the value of life was taken as 2.9% (17). Sensitivity analysis of NHGDP loss was also computed using 5% and 10% of discounted rates of interest.

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172 The estimates in INR were converted to \$ (PPP) using OECD estimates for the year 2020(24). People
173 aged more than 75 years were excluded from the analysis as the life expectancy of West Bengal is 72
174 years.
175 Details of the input parameters used in the study are described in Table-I.

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Table I: Input parameters for the study

Parameters	Values	Reference	Till Date
Number of cases	21,18,620	(19)	31st Dec-2022
Number of deaths	21,532	(19)	31st Dec -2022
Discount rate for value of life	2.90%	(17)	NA
Life Expectancy at Birth in West Bengal		(18)	NA
Male	71 Years		
Female	73 Years		
Per capita Gross Domestic Product (GDP) in West Bengal	121267 INR/year	(21)	NA
Per capita health expenditure in West Bengal	1643 INR/year	(22)	NA
Excess Death Estimates GBD in West Bengal	220000 deaths	(25)	31 st Dec-2021
Excess Death Estimates WHO in West Bengal	220900 deaths	(26)	20 th May-2021

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Validation
The data on COVID-19 were compiled from official bulletins, reports and newspaper articles (19,25–28). Data on life expectancy, per capita GDP and per capita health expenditures were collected from Central and State government published reports(18,21,22). NHGDP losses were computed based on the works by Kirigiaet al. (29,30). Discounting of value of life was based on values reported in Shanmugam (2011)(17).The methodology and results are written in accordance to the Consolidated Health Economic Evaluation Reporting Standards (CHEERS) 2022 checklist (Supplementary 1)(31).

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Patient and public involvement
The analysis employed in the study used secondary data and did not involve the public and/or patients directly in any of the phases including plan, design or reporting.
Raw data has been uploaded in the following link: https://datadryad.org/stash/share/XP_Zo452CqM-HYuLnhZHBjreokOm9A-h_Z7CEadGYuo (49).

RESULTS

In West Bengal, due to COVID-19, the NHGDP loss amounts to \$0.92 billion, with approximately 60% of NHGDP loss due to deaths among males (Table II). The major proportion of NHGDP loss is borne by the middle age-group of 46-60 years. The NHGDP loss associated with each death is estimated to be \$55,171. There is an age-wise continuous decline in NHGDP loss/death on one side and the increasing percentage of NHGDP loss till the 46-60 years age group that falls steeply thereafter in the 61-75 years age-group (Figure 1). NHGDP loss per death is higher for females compared to males in across all age-groups.

Table II NHGDP loss in West Bengal

Age (years)	NHDP Loss (\$)			NHGDP Loss/Death (\$)
	Male	Female	Total	
0-15	6412235	3714824	10147078	157085
16-30	30687798	23175408	53944400	147371
31-45	135232896	68065679	204570269	121805
46-60	275500238	178696130	458996439	82305
61-75	92458934	85121669	190603899	21279
Total	540292101	358773711	918262085	55171

< Insert Figure 1 >

Scenario analysis

The NHGDP losses were also estimated using the excess death measures provided by GBD and WHO(25,27,28,32). In these analyses, the calculation is based on the assumption that the proportion of excess COVID deaths in India remain similar across age and gender in West Bengal state. The calculated NHGDP loss amount to \$9.38 billion and \$9.42 billion based on the GBD and WHO estimates respectively (Table III). NHGDP loss per death is higher for females compared to males across all age-groups.

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209 **Table III NHGDP loss in West Bengal due to excess deaths**

Age (years)	NHGD Loss (\$) GBD estimates			NHGDP loss/death (\$)	NHGDP Loss (\$) (WHO Estimates)			NHGDP loss/death (\$)
	Male	Female	Total		Male	Female	Total	
0-15	65650465	38533987	104386078	157085	65919035	38691626	104813112	157085
16-30	313677606	237173128	551678108	147371	314960833	238143382	553934973	147371
31-45	1381069747	695588246	2089637409	121805	1386719578	698433834	2098185926	121805
46-60	2815061969	1825819090	4689931876	82305	2826578132	1833288349	4709117961	82305
61-75	944692129	869583873	1947366994	21279	948556779	873141262	1955333496	21279
Total	5520151917	3666698323	9383000466	55174	5542734357	3681698453	9421385468	55174

211 **Sensitivity Analysis**

212 Table III shows that the NHGDP loss increases to \$1.3 billion when assumed AAD to be starting age of
213 each age group range (Table IV).

214 **Table IV: Sensitivity Analysis**

Age (years)	NHGDP Loss (\$)		
	Males	Females	Total
0-15	6719947	3880750	10616803
16-30	32552907	24480243	57099428
31-45	150723664	75173447	226935166
46-60	349348723	220463003	573729920
61-75	279338344	185344342	475313319
Total	818683585	509341786	1343694636

215 NHGDP loss computed using 5 and 10 percent as discounted rate of interest shows that the loss
216 declines to \$0.767 billion and further to \$ 0.549 billion respectively (Table IV).

217 **Table IV: Sensitivity Analysis using discount values of 5% and 10% respectively**

Age (years)	NHGDP Loss (r=0.05) in \$			NHGDP Loss (r=0.10) in \$		
	Males	Females	Total	Males	Females	Total
0-15	4350449	2501288	6858008	2307500	1319459	3627352
16-30	21538141	16119536	37688570	11746019	8721354	20470426
31-45	102883253	51157394	154681695	61320986	30023608	91469746
46-60	233174181	148864134	385387606	163987864	101814095	267216402
61-75	89647611	80907665	182966478	83404013	71959308	166383380
Total	451593636	299550017	767582357	322766382	213837824	549167306

DISCUSSION

Key findings of this study

The findings of this study reflect that, the NHGDP Loss in West Bengal is substantially high at \$0.92 billion, and the NHGDP loss attributable to the 46-60 age-group to be the highest. Majority (60%) of the NHGDP loss is found to be borne by males. NHGDP loss per death is higher for females compared to males across all age-groups. This higher estimate could be due to higher life expectancy experienced by the females in West Bengal(18) .

Estimation of excess deaths across 74 countries including 31 low-and middle-income countries (LMIC) has been conducted by GBD, and the estimated mortality figures reflect a significantly higher number of deaths than reported(26). As per WHO projections there could be over 4 million excess deaths in India (27,28,33,34). Both these estimates are found to be more than ten times the reported figures for the state of West Bengal (27,28,35). Various published articles based on civil registration system support these estimates(32), but the Government of India has objected to the approach employed to compute the excess deaths due to the associated risk of bias (34). The generated estimates may involve some degree of bias; therefore the fact that there are excess deaths during the tenure needs to be seriously investigated. Given this background, the estimates for NHGDP loss have been computed considering the excess deaths to be ten times the actual numbers. The NHGDP loss estimates amount to \$9.38 billion and \$9.42 billion respectively based on the GBD and WHO estimates.

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238 In our analysis, the NHGDP loss computed using Average age of death (AAD) was found to vary with
239 the age of death. To take account of this factor, a sensitivity analysis was carried out by considering
240 the lower age of the interval as the average age of death. NHGDP loss showed an increase from \$0.92
241 billion to \$1.2 billion.

242 The NHGDP loss also varies depending on the discounting rate. Previous calculation from India
243 considered a discount rate of 2.9% (17). For our sensitivity analysis this was changed to 5% and 10%,
244 the NHGDP loss showed a decline to \$0.767 billion and \$0.549 billion respectively.

245 There is a paucity of literature which accounts for the NHGDP loss associated with COVID-19 deaths.
246 While similar studies have been conducted in other countries(30,35),there is only one study based in
247 India which looks into the NHGDP loss but this study considered data only till August 12th, 2020 (37).
248 This study uses a discount rate of 4% which is different from the discount rate used in our study.
249 Further, the study did not consider NHGDP loss of male and females separately as the analysis was
250 considered at all-India level. Moreover, two major peaks of Covid-19, September 2020 and April 2021,
251 which had been most devastating in terms of life loss in West Bengal, are also considered in our study
252 (38). The present study is much more comprehensive with scenario analysis using excess deaths
253 predicted by GBD and WHO and sensitivity analysis which are standard requirements for such models
254 (26,28,29,33).

255 This study also accounts for the NHGDP losses separately for males and females. This is important to
256 highlight the NHGDP losses borne by males and females separately as otherwise the huge economic
257 loss borne by the untimely deaths of females would remain invisible. Losses on account of female
258 deaths remain unaccounted in GDP calculations due to the underestimationof the roles females in
259 domestic and family care providing activities in households(39).

260 The findings of this study are corroborated by the findings of study from China which demonstrates
261 the effect of COVID-19 beyond the healthcare system and identifies that the potential productivity
262 losses caused by a pandemic may by far exceed the healthcare cost(36). The huge losses in one single
263 state, i.e. West Bengal, in India give us a picture of the potential overall loss incurred in the country.
264 Our estimates ofNHGDP loss in West Bengaljustifies the redirection of resources from other sectors
265 of the economy to strengthen healthcare systems(35). Other studies have also identified the extent
266 of the impact of COVID-19 on the world economy and its importance to institute future policies to
267 protect society(40,41).

268 ***What is already known on this topic***

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Enseignement Supérieur (ABES).

The COVID-19 pandemic has impacted economies worldwide by disrupting the socio-economic fabric of the societies, and has manifested in terms of increased risk of extreme poverty and under-nourishment levels(1). The pandemic has far-fetched consequences in terms of its indirect effects due to morbidity and mortality(2). Economic burden associated with COVID-19 has been estimated across various countries around the globe, such as Africa(42), China(36), India(10), Iran(43), Russia(44), Spain(45), Switzerland(46), United States(47) and Vienna(48). As per US estimates, GDP loss associated with COVID-19 would amount to a cumulative US\$1.4 trillion by 2030(47). In China, the estimated health-care and societal costs associated with COVID-19 amounted to 4.26 billion Chinese yuan(35). Economic burden associated with inpatient cases of COVID-19 alone amounted to \$1.4 billion in Iran(43). The socio-economic burden of COVID-19 in the Russian Federation amounted to approximately \$71.1 billion i.e. 4 % of their GDP(43). The existing studies indicate the huge economic burden imposed by the pandemic. Fiscal value or NHGDP loss has been estimated by very few countries. The fiscal value or NHGDP loss in China amounts to Int\$ 924 million(35) while that in India amounts to Int\$ 815 million(37).

What this study adds

This study adds to the existing limited literature on NHGDP loss attributable to COVID-19. This study substantiates the existing study based on West Bengal state in India since it takes into consideration two most devastating peaks (in terms of life loss) of COVID-19, one in September 2020 and another in April 2021 which had not been considered in the previous study (37). Further, the previous study based in India did not consider the attributable losses separately for males and females; a dimension addressed by this study(36). This study has also conducted sensitivity analysis by varying the AAD and considering the impact of excess deaths predicted by GBD and WHO.

For accessibility and usability, we have created a free web-based, user-friendly tool, <https://covidnonhealthgdp.cphr-mant.org>, where users can enter data from their respective countries for calculating the NHGDP loss for their region. The 'calculate' function provides results, and 'table' function can be used to view final results table. Users can also download a pdf report using the 'Download Report' function.

LIMITATIONS

This study did not consider the costs associated with illness and recovery, i.e. absence from work and costs associated with the treatment. GDP per capita does not capture the inequality in the distribution of resources among people and households, and implies that the average income per capita might

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3 301 remain unchanged but the distribution of income might change. This has considerable implications at
4 302 the household level(16). Further, GDP only captures economic activities associated with market
5 303 transactions, and does not take into consideration the valuation of domestic activities(16). For
6 304 example, the value of labour of a woman who chooses to stay at home to conduct household chores
7 305 and raise children is not accounted for in GDP estimations(16). GDP also does not account for the cost
8 306 of production and consumption externalities such as pollution, climate change and the cost of
9 307 consuming abusive substances (like smoking and alcohol) (16). This studyalso did not account for the
10 308 psychological pain associated with the death of one’s near and dear ones due to COVID-19.
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22 310 **CONCLUSION**

23 311 This paper tried to contribute to the literature on the economic burden of COVID-19 deaths in West
24 312 Bengal. The NHGDP loss (computed using state-level reported death figures) accounts for 0.2% of the
25 313 State Domestic Product (SDP) of West Bengal. If the excess deaths reported by WHO and GBD are
26 314 considered then the NHGDP loss is found to be equivalent to 1.8% of the SDP of West Bengal. The loss
27 315 is found to vary with the AAD and the discounting rate of interest. The NHGDP loss is significant
28 316 especially for a state like West Bengal where a fifth of the population lives below the poverty line(48).
29 317 The evidence from this paper substantiates the argument for the requirement of improved health
30 318 infrastructure and greater allocation of funds to address the basic public health demands. The findings
31 319 of this study re-establishes that health and the economy are inseparably interlinked, probing the
32 320 health and financial sectors of the economies to re-consider the laid down priorities to ensure
33 321 sustainable improvements in population health, preparedness andeconomic performance.
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44 323 Figure 1: Value of NHGDP loss per death and Percentage of NHGDP loss by Age
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46
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51 327 **Contribution statement:**

52
53 328 The conception and design of the study, or acquisition of data, or analysis and interpretation of data
54 329 – PB, DJ, NM, MSN. Drafting the article or revising it critically for important intellectual content –DJ,
55 330 PB, NM. Final approval of the version to be submitted – JM, AB, DJ, NM, MSN.
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Patient consent for publication: Not required.

Data sharing statement:

Extra data can be accessed via the Dryad data repository at <http://datadryad.org/> with the doi: dryad.573n5tbc4

Ethical statement: The study has been conducted using publicly available data. No ethical approvals were sort for this study.

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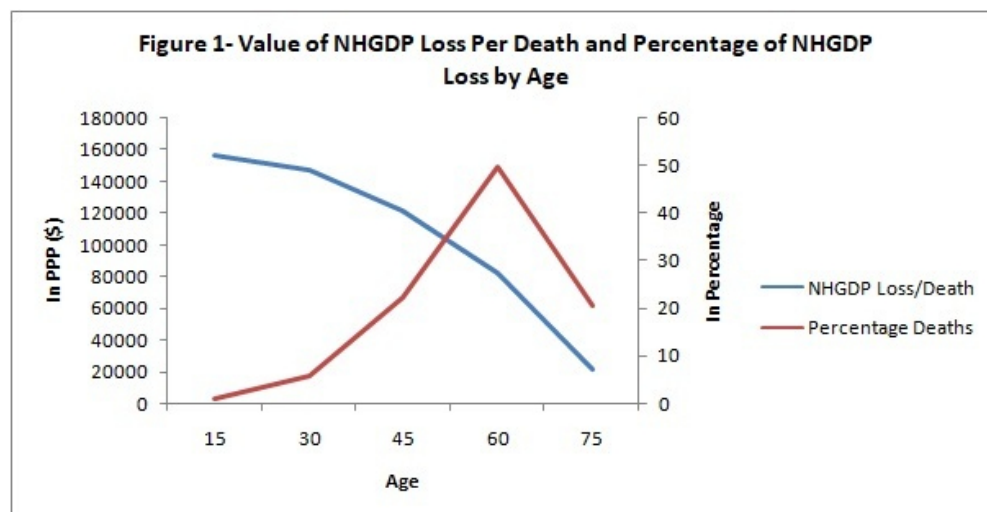
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Value of NHGDP Loss Per Death and Percentage of NHGDP Loss by Age

161x83mm (96 x 96 DPI)

Supplementary 1: CHEERS2022Checklist

	Item	GuidanceforReporting	Reported insection
TITLE			
Title	1	Identify the study as an economic evaluation and specify theinterventionsbeingcompared.	Page 1, Lines 1 &2
ABSTRACT			
Abstract	2	Provide a structured summary that highlights context, key methods,resultsandalternativeanalyses.	Page 2, Lines 55-67
INTRODUCTION			
Background andobjectives	3	Give the context for the study, the study question and its practicalrelevancefordecisionmakinginpolicy orpractice.	Page 3-4, Lines 86-132
METHODS			
Health economic analysis plan	4	Indicatewhetherthehealtheconomicanalysisplanwasdevelopedand whereavailable.	Page 6, Lines 176-180
Studypopulation	5	Describe characteristics of the study population (such as agerange,demographics,socioeconomic,orclinicalcharacteristics).	Page 5, Line 145-146
Setting and location	6	Providerelevantcontextualinformationthatmayinfluencefindings.	Page 5, 167-170
Comparators	7	Describetheinterventions orstrategies beingcomparedandwhychosen.	NA
Perspective	8	Statetheperspective(s)adoptedbythestudyandwhychosen.	Page 4, 134-141
Timehorizon	9	Statethetimehorizonforthestudy andwhy appropriate.	Page 4, 125-129; Page 5, Line 160
Discount rate	10	Reportthediscount rate(s)andreasonchosen.	Page 6, Table 1
Selectionofoutcomes	11	Describe what outcomes were used as the measure(s) of benefit(s)andharm(s).	NA
Measurement ofoutcomes	12	Describe how outcomes used to capture benefit(s) and harm(s)weremeasured.	NA
Valuationofoutcomes	13	Describethepopulationandmethods usedtomeasureandvalueoutcomes.	Pages 4-6, Lines 134-171
Measurement andvaluationofresourc es andcosts	14	Describehowcostswerevalued.	Page 5, Line 148
Currency,pricedate,a ndconversion	15	Reportthedatesoftheestimated resourcequantitiesandunitcosts,plusthecurrencyandyearofconversion.	Page 5, Line 170
Rationaleand descriptionofmodel	16	Ifmodellingis used,describeindetailandwhy used.Report ifthemodel ispublicly availableandwhere it canbeaccessed.	NA
Analytics andassumpti ons	17	Describeanymethodsforanalysingorstatisticallytransformingdata,anyextrapolatio nmethods,andapproachesforvalidatinganymodelused.	Page 5-6, 160-171
Characterizing heterogeneity	18	Describe any methods used for estimating how the results of the studyvaryforsub-groups.	Page 5, 164-171
Characterizing distributionaleffects	19	Describehowimpacts aredistributedacrossdifferentindividuals or adjustmentsmadetorelectpriority populations.	Page 5, 162-164
Characterizing uncertainty	20	Describemethodstocharacterizeanysourcesofuncertaintyintheanalysis.	Page 5, 166-168
Approach toengagement withpatients and othersaffected bythestudy	21	Describe any approaches to engage patients or service recipients, thegeneral public, communities, or stakeholders (e.g., clinicians or payers) inthedesignof thestudy.	NA
RESULTS			
Studyparameters	22	Report all analytic inputs (e.g., values, ranges, references) includinguncertaintyordistributionalassumptions.	Page 6, Table 1
Summary of mainresults	23	Report the mean values for the main categories of costs and outcomes ofinterestandsummarisethem inthemostappropriateoverallmeasure.	Page 7, Table 2
Effect ofuncertainty	24	Describehowuncertaintyaboutanalyticjudgments,inputs, orprojections affect findings. Report the effect of choice of discount rate and time horizon,ifapplicable.	Pages 7-8, Lines 197-212
Effect of engagementwithpatient sandothersaffectedbyth estudy	25	Report on any difference patient/service recipient, general public, community,orstakeholderinvolvementmadetotheapproachorfindingsofthestud y	NA
DISCUSSION			
Study findings,limitations, generalizability, andcurrentknowled ge	26	Reportkeyfindings,limitations,ethicalorequityconsiderationsnotcaptured,andhow thesecouldimpactpatients, policy, orpractice.	Pages 8-11, Lines 217-303
OTHERRELEVANTINFORMATION			
Sourceoffunding	27	Describe how the study was funded and any role of the funder intheidentification,design,conduct,and reportingoftheanalysis	Page 12, Line 324
Conflictsof interest	28	Reportauthorsconflictsof interestaccordingtojournalor InternationalCommitteeofMedicalJournalEditorsrequirements.	Page 12, Line 325-326

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