

BMJ Open Estimation of non-health gross domestic product (NHGDP) loss due to COVID-19 deaths in West Bengal, India

Paramita Bhattacharya ¹, Denny John ², Nirmalaya Mukherjee ¹, Narassima MS ³, Jaideep Menon ⁴, Amitava Banerjee ⁵

To cite: Bhattacharya P, John D, Mukherjee N, *et al.* Estimation of non-health gross domestic product (NHGDP) loss due to COVID-19 deaths in West Bengal, India. *BMJ Open* 2023;**13**:e072559. doi:10.1136/bmjopen-2023-072559

► Prepublication history and additional supplemental material for this paper are available online. To view these files, please visit the journal online (<http://dx.doi.org/10.1136/bmjopen-2023-072559>).

Received 15 February 2023
Accepted 13 September 2023



© Author(s) (or their employer(s)) 2023. Re-use permitted under CC BY-NC. No commercial re-use. See rights and permissions. Published by BMJ.

¹Centre for Public Health Research, Manbhumi Ananda Ashram Nityananda Trust, Kolkata, West Bengal, India

²Faculty of Life and Allied Health Sciences, MS Ramaiah University of Applied Sciences, Bengaluru, Karnataka, India

³Great Lakes Institute of Management, Manamai Village, Tamilnadu, India

⁴Department of Cardiology, Amrita Institute of Medical Sciences & Research Centre, Kochi, Kerala, India

⁵Institute of Health Informatics, University College London, London, UK

Correspondence to

Dr Denny John;
djohn1976@gmail.com

ABSTRACT

Objectives The state of West Bengal witnessed a 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 non-health gross domestic product (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 the cost-of-illness approach. Future NHGDP losses were discounted at 3%. Excess death estimates by the 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 21 532 deaths in West Bengal from 17 March 2020 to 31 December 2022 decreased the future NHGDP by \$0.92 billion. Nearly 90% of loss was due to deaths occurring in the age group of 30 years and above. Majority of the NHGDP loss was borne by the 46–60 years age group. NHGDP loss/death was \$55,171; however, the average loss/death declined with rise in age. Based on the GBD and WHO excess death estimates, the NHGDP loss increased to \$9.38 billion and \$9.42 billion, respectively. When the lower age interval is considered as AAD, the NHGDP loss increased to \$1.3 billion. At 5% and 10% discount rates, the losses reduced to \$0.767 billion and \$0.549 billion, respectively.

Conclusions Results from the study suggest that COVID-19 contributed to a 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 economic argument for better infection control strategies across the globe to minimise the impact of COVID-19.

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

STRENGTHS AND LIMITATIONS OF THIS STUDY

- ⇒ This study evaluates the NHGDP losses associated with COVID-19 deaths in West Bengal.
- ⇒ 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 AAD.
- ⇒ This study did not consider the costs associated with illness and recovery.
- ⇒ Per capita GDP does not capture the inequality in the distribution of resources among people and households.

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 spillover 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 three 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 per capita GDP (PCGDP) and with weaker healthcare infrastructure.⁹ Patients with chronic conditions, particularly among poor, rural and marginalised sections, experienced difficulties in accessing healthcare and were severely affected both socially and financially by the pandemic.⁹ A 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 were reduced due to the incidence of COVID infection. The cost of productivity lost for individuals aged 40–49 years was found to be highest in the Kerala-based study.¹⁰

With regard to the health effects of the pandemic, it is well-known that not only the underlying mortality risk and diseases but also the socioeconomic 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*, "...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 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% 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 infection.^{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 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, that is, 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:

$$\text{NHGDP Loss} = \sum_{i=1}^n D_i \times \text{DYLL}_i \times \text{NHGDPPC}_i \quad | i = 1, 2, \dots, n,$$

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.

$$\text{DYLL}_i = \frac{(1 - e^{-r \text{YLL}_i})}{r}$$

$$\text{NHGDPPC} = \text{GDPPC} - \text{PCHE}$$

GDPPC=GDP per capita

PCHE=per capita health expenditure

r=discounted rate for value of life.¹⁷

$\text{YLL}_i = \text{LE} - \text{AAD}$

where YLL_i = undiscounted years of life lost

LE=life expectancy

AAD=average age of death.

The population data, COVID-19 deaths data (from 17 March 2020 to 31 December 2022), life expectancy (LE) 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 group brackets, and considered the legal minimum age for working, that is, 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, the 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.

The estimates in INR were converted to \$ Purchasing Power Parity (PPP) using Organisation for Economic Co-operation and Development (OECD) estimates for the year 2020.²⁴ People aged more than 75 years were

Table 1 Input parameters for the study

Parameter	Value	Reference	Until
Number of cases	2 118 620	19	31 December 2022
Number of deaths	21 532	19	31 December 2022
Discount rate for value of life	2.90%	17	NA
LE at birth in West Bengal		18	NA
Males	71 years		
Females	73 years		
PCGDP in West Bengal	121 267 INR/year	21	NA
PCHE in West Bengal	1643 INR/year	22	NA
Excess death estimates by GBD in West Bengal	220 000 deaths	25	31 December 2021
Excess death estimates by WHO in West Bengal	220 900 deaths	26	20 May 2021

GBD, Global Burden of Disease; LE, life expectancy; NA, not available; PCGDP, per capita gross domestic product; PCHE, per capita health expenditure.

excluded from the analysis as the LE of West Bengal is 72 years.

Details of the input parameters used in the study are described in [table 1](#).

Validation

The data on COVID-19 were compiled from official bulletins, reports and newspaper articles.^{19 25–28} Data on LE, PCGDP and PCHE were collected from central and state government published reports.^{18 21 22} NHGDP losses were computed based on the works by Kirigia *et al.*^{29 30} Discounting of value of life was based on values reported by Shanmugam.¹⁷ The methodology and results are written in accordance to the Consolidated Health Economic Evaluation Reporting Standards (CHEERS) 2022 checklist (online supplemental file 1).³¹

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.³²

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 men ([table 2](#)). 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 an increasing percentage of NHGDP loss until the 46–60 years age group that falls thereafter in the 61–75 years age group ([figure 1](#)). NHGDP loss/death is higher for females than for males across all age groups.

Scenario analysis

The NHGDP losses were also estimated using the excess death measures provided by GBD and WHO.^{25 27 28 33} In these analyses, the calculation is based on the assumption that the proportion of excess COVID deaths in India remains similar across age and gender in West Bengal. The calculated NHGDP losses amount to \$9.38 billion and \$9.42 billion based on the GBD and WHO estimates, respectively ([table 3](#)). NHGDP loss/

Table 2 NHGDP loss in West Bengal

Age (years)	NHGDP loss (\$)			NHGDP loss/death (\$)
	Males	Females	Total	
0–15	6412 235	3714 824	10 147 078	157 085
16–30	30687 798	23 175 408	53 944 400	147 371
31–45	135232 896	68 065 679	204 570 269	121 805
46–60	275 500 238	178 696 130	458 996 439	82 305
61–75	92 458 934	85 121 669	190 603 899	21 279
Total	540 292 101	358 773 711	918 262 085	55 171

NHGDP, non-health gross domestic product.

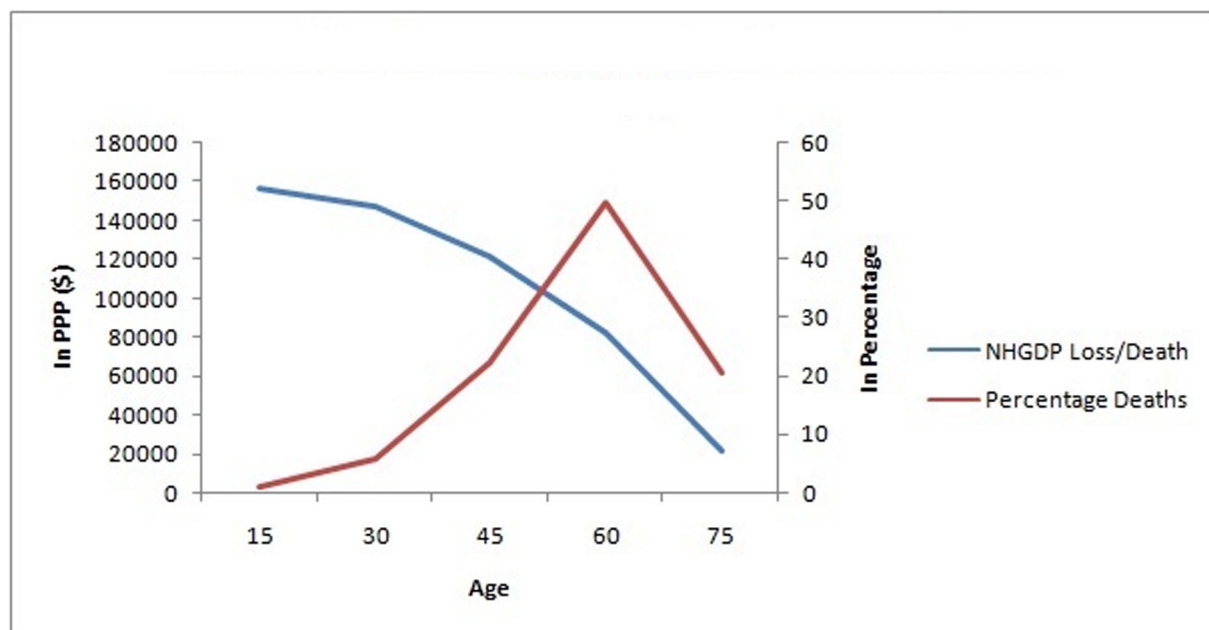


Figure 1 Value of NHGDP loss/death and percentage of NHGDP loss by age. NHGDP, non-health gross domestic product; PPP, Purchasing Power Parity.

death is higher for females compared with males across all age groups.

Sensitivity analysis

Table 3 shows that the NHGDP loss increases to \$1.3 billion when assumed average age of death (AAD) to be starting age of each age group range (table 4).

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/death is higher for females compared with males across all age groups. This higher estimate could be due to higher LE experienced by females in West Bengal.¹⁸

Estimation of excess deaths across 74 countries including 31 LMICs 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.^{27–29 34} Both these estimates are found to be more than 10 times the reported figures for the state of West Bengal.^{27 28 35} Various published articles based on civil registration system support these estimates,³³ but the Government of India has objected to the approach employed to compute the excess deaths due to the associated risk of bias.²⁹ 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 10 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.

In our analysis, the NHGDP loss computed using AAD was found to vary with the age of death. To take account of this factor, a sensitivity analysis was carried out by

Table 3 NHGDP loss in West Bengal due to excess deaths

Age (years)	NHGDP loss (\$) (GBD estimates)			NHGDP loss/death (\$)	NHGDP loss (\$) (WHO estimates)			NHGDP loss/death (\$)
	Males	Females	Total		Males	Females	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

NHGDP, non-health gross domestic product.

Table 4 Sensitivity analysis

Age (years)	NHGDP loss (\$)		
	Males	Females	Total
0–15	6 719 947	3 880 750	10 616 803
16–30	32 552 907	24 480 243	57 099 428
31–45	150 723 664	75 173 447	226 935 166
46–60	349 348 723	220 463 003	573 729 920
61–75	279 338 344	185 344 342	475 313 319
Total	818 683 585	509 341 786	1 343 694 636

NHGDP loss computed using 5% and 10% as discounted rate of interest shows that the loss decline to \$0.767 billion and further to \$0.549 billion, respectively (table 5).
NHGDP, non-health gross domestic product.

considering the lower age of the interval as the AAD. NHGDP loss showed an increase from \$0.92 billion to \$1.2 billion.

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

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,^{30 35} there is only one study based in India which looks into the NHGDP loss; and, this study considered data only until 12 August 2020.³⁶ This study uses a discount rate of 4% which is different from the discount rate used in our study. Further, the study did not consider NHGDP loss of males and females separately as the analysis was considered at all-India level. Moreover, two major peaks of COVID-19, September 2020 and April 2021, which had been the most devastating in terms of loss of life in West Bengal, are also considered in our study.³⁷ The present study is much more comprehensive with scenario analysis using excess deaths predicted by GBD and WHO and sensitivity analysis, which are standard requirements for such models.^{26 28 29 34}

This study also accounts for the NHGDP losses separately for males and females. It is important to highlight the NHGDP losses borne by males and females separately as otherwise the huge economic loss borne by the untimely deaths of females would remain invisible. Losses on account of female deaths remain unaccounted in GDP calculations due to the underestimation of the roles females play in domestic and family care providing activities in households.³⁸

The findings of this study are corroborated by the findings of a study from China 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.³⁹ The huge losses in one single state, that is, West Bengal, in India give us a picture of the potential overall loss incurred in the country. Our estimates of NHGDP loss in West Bengal justifies the redirection of resources from other sectors of the economy to strengthen healthcare systems.³⁵ 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.^{40 41}

What is already known on this topic

The COVID-19 pandemic has impacted economies worldwide by disrupting the socioeconomic fabric of the societies, and has manifested in terms of increased risk of extreme poverty and undernourishment 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,³⁹ India,¹⁰ Iran,⁴³ Russia,⁴⁴ Spain,⁴⁵ Switzerland,⁴⁶ USA⁴⁷ 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 healthcare and societal costs associated with COVID-19 amounted to ¥4.26 billion.³⁵ Economic burden associated with inpatient cases of COVID-19 alone amounted to \$1.4 billion in Iran.⁴³ The socioeconomic burden of COVID-19 in the Russian Federation amounted to approximately \$71.1 billion, that is, 4% of their GDP.⁴³ The existing studies indicate the huge economic burden

Table 5 Sensitivity analysis using discount values of 5 and 10%, respectively

Age (years)	NHGDP loss (\$) (r=0.05)			NHGDP loss (\$) (r=0.10)		
	Males	Females	Total	Males	Females	Total
0–15	4 350 449	2 501 288	6 858 008	2 307 500	1 319 459	3 627 352
16–30	21 538 141	16 119 536	37 688 570	11 746 019	8 721 354	20 470 426
31–45	102 883 253	51 157 394	154 681 695	61 320 986	30 023 608	91 469 746
46–60	233 174 181	148 864 134	385 387 606	163 987 864	101 814 095	267 216 402
61–75	89 647 611	80 907 665	182 966 478	83 404 013	71 959 308	166 383 380
Total	451 593 636	299 550 017	767 582 357	322 766 382	213 837 824	549 167 306

NHGDP, non-health gross domestic product.

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\$924million³⁵ while that in India amounts to Int\$815million.³⁶

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 the West Bengal state in India since it takes into consideration two most devastating peaks (in terms of loss of life) of COVID-19, one in September 2020 and another in April 2021, which had not been considered in the previous study.³⁶ Further, the previous study based in India did not consider the attributable losses separately for males and females, a dimension addressed by this study.³⁹ 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, that is, absence from work and costs associated with the treatment. PCGDP does not capture the inequality in the distribution of resources among people and households, and implies that the average income per capita might remain unchanged but the distribution of income might change. This has considerable implications at the household level.¹⁶ Further, GDP only captures economic activities associated with market transactions and does not take into consideration the valuation of domestic activities.¹⁶ 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 in GDP estimations.¹⁶ 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).¹⁶ This study also did not account for the psychological pain associated with the death of one's near and dear ones due to COVID-19.

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 one-fifth of the population lives below the poverty line.⁴⁸

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 economy are inseparably interlinked, probing the health and financial sectors of the economies to reconsider the laid down priorities to ensure sustainable improvements in population health, preparedness and economic performance.

Twitter Amitava Banerjee @amibanerjee1

Acknowledgements The authors acknowledge the inputs provided by Dr Geetha Menon, Senior Scientist, ICMR-NIMS, New Delhi, India, for improving the manuscript.

Contributors The conception and design of the study, or acquisition of data, or analysis and interpretation of data—PB, DJ, NM, NMS. 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, NMS. DJ is the responsible for the overall content as the guarantor.

Funding The authors have not declared a specific grant for this research from any funding agency in the public, commercial or not-for-profit sectors.

Competing interests None declared.

Patient and public involvement Patients and/or the public were not involved in the design, or conduct, or reporting, or dissemination plans of this research.

Patient consent for publication Not applicable.

Ethics approval Not applicable.

Provenance and peer review Not commissioned; externally peer reviewed.

Data availability statement Data are available in a public, open access repository. All data that is incorporated into the article is available from the references mentioned. Raw data has been uploaded in the following link: https://datadryad.org/stash/share/XP_Zo452CqM-HYuLnhZHBjreokOm9A-h_Z7CEadGYuo.

Supplemental material This content has been supplied by the author(s). It has not been vetted by BMJ Publishing Group Limited (BMJ) and may not have been peer-reviewed. Any opinions or recommendations discussed are solely those of the author(s) and are not endorsed by BMJ. BMJ disclaims all liability and responsibility arising from any reliance placed on the content. Where the content includes any translated material, BMJ does not warrant the accuracy and reliability of the translations (including but not limited to local regulations, clinical guidelines, terminology, drug names and drug dosages), and is not responsible for any error and/or omissions arising from translation and adaptation or otherwise.

Open access This is an open access article distributed in accordance with the Creative Commons Attribution Non Commercial (CC BY-NC 4.0) license, which permits others to distribute, remix, adapt, build upon this work non-commercially, and license their derivative works on different terms, provided the original work is properly cited, appropriate credit is given, any changes made indicated, and the use is non-commercial. See: <http://creativecommons.org/licenses/by-nc/4.0/>.

ORCID iDs

Paramita Bhattacharya <http://orcid.org/0000-0003-3871-9400>
 Denny John <http://orcid.org/0000-0002-4486-632X>
 Nirmalaya Mukherjee <http://orcid.org/0000-0001-5137-1010>
 Narassima MS <http://orcid.org/0000-0002-4113-430X>
 Jaideep Menon <http://orcid.org/0000-0002-0786-8123>
 Amitava Banerjee <http://orcid.org/0000-0001-8741-3411>

REFERENCES

- 1 International Labour Organization, Food and Agricultural Organization, International Fund for Agricultural Development, World Health Organization. Impact of COVID-19 on people's livelihoods, their health and our food systems. 2020. Available: <https://www.who.int/news/item/13-10-2020-impact-of-covid-19-on-people's-livelihoods-their-health-and-our-food-systems#:~:text=The%20economic%20and%20social%20disruption,the%20end%20of%20the%20year>
- 2 Abiad A, Arao M, Dagli S, *et al.* The economic impact of the COVID-19 outbreak on developing Asia. ADB Briefs. Manila, Philippines Asian Development Bank; 2020. Available: <https://www.adb.org/publications/economic-impact-covid-19-developing-asia>
- 3 Ministry of Finance, Government of India. Economic survey 2021-22 [New Delhi]. 2022. Available: <https://www.indiabudget.gov.in/economicsurvey/doc/echapter.pdf>
- 4 World Health Organization I. Coronavirus disease (COVID-19) situation update Report-104. 2022. Available: https://cdn.who.int/media/docs/default-source/wrindia/situation-report/india-situation-report-104.pdf?sfvrsn=a1af74b3_4
- 5 World Health Organization. *Coronavirus disease 2019 (COVID-19) Situation Report - 73*. World Health Organization, 2020.
- 6 Kar SK, Ransing R, Arafat SMY, *et al.* Second wave of COVID-19 pandemic in India: barriers to effective governmental response. *EClinicalMedicine* 2021;36:100915.
- 7 Yengkom S. Bengal's daily case surge smashes pandemic record [Times of India]. 2022. Available: <https://timesofindia.indiatimes.com/city/kolkata/bengals-daily-case-surge-smashes-pandemic-record/articleshow/88798148.cms>
- 8 Xu T, Deb P. State-level health and economic impact of COVID-19 in India. *IMF Working Papers* 2021;2021:1.
- 9 Singh K, Kondal D, Mohan S, *et al.* Health, psychosocial, and economic impacts of the COVID-19 pandemic on people with chronic conditions in India: a mixed methods study. *BMC Public Health* 2021;21:685.
- 10 John D, Narassima MS, Menon J, *et al.* Estimation of the economic burden of COVID-19 using disability-adjusted life years (Dalys) and productivity losses in Kerala, India: a model-based analysis. *BMJ Open* 2021;11:e049619.
- 11 Grossman M. On the concept of health capital and the demand for health. *J Polit Econ* 1972;80:223-55.
- 12 Chisholm D, Stanciole AE, Tan Torres Edejer T, *et al.* Economic impact of disease and injury: counting what matters. *BMJ* 2010;340:bmj.c924.
- 13 World Health Organization. WHO guide to identifying the economic consequences of disease and injury. Geneva World Health Organization; 2009. Available: <https://apps.who.int/iris/handle/10665/137037>
- 14 Mondal BK, Sahoo S, Paria P, *et al.* Multi-sectoral impact assessment during the 1ST wave of COVID-19 pandemic in West Bengal (India) for sustainable planning and management. *Arab J Geosci* 2021;14.
- 15 Government of West Bengal D of F. Administrative report. 2020. Available: <http://www.westbengalforest.gov.in/upload/publication/AnnualAdminReport2019-20.pdf>
- 16 Callen T. Gross domestic product: an economy's all [International Monetary Fund]. 2020. Available: <https://www.imf.org/external/pubs/ft/fandd/basics/gdp.htm>
- 17 Shanmugam KR, editor. Discount rate for health benefits and the value of life in India. *Econ Res Int* 2011;2011:1-5.
- 18 Office of the Registrar General & Census Commissioner, India (ORGI). Sample registration System(SRS)-Abridged life tables 2015-2019. Report no.: SRS-Abridged_Life_Tables_2015-2019. n.d. Available: <https://censusindia.gov.in/nada/index.php/catalog/43473>
- 19 Government of West Bengal D of H& FW. West Bengal COVID-19 health bulletin. n.d. Available: https://www.wbhealth.gov.in/uploaded_files/corona/WB_DHFW_Bulletin_7TH_JAN_REPORT_FINAL.pdf
- 20 India Census. West Bengal population. n.d. Available: <https://www.indiacensus.net/states/west-bengal>
- 21 Reserve Bank of India. Handbook of Statistics on the Indian economy 2020-21. 2022. Available: <https://www.rbi.org.in/scripts/AnnualPublications.aspx?head=Handbook%20of%20Statistics%20on%20Indian%20Economy>
- 22 Institute of Policy Research Studies. West Bengal budget analysis 2021-22. 2022. Available: https://prsiindia.org/files/budget/budget_state/west-bengal/2021/West%20Bengal_Budget_Analysis_2021-22.pdf
- 23 Government of India M of L and E. Children and work. 2019. Available: <https://labour.gov.in/sites/default/files/Updated%20Status%20on%20Child%20Labour.pdf>
- 24 Purchasing power parity. n.d. Available: <https://data.oecd.org/conversion/purchasing-power-parities-ppp.htm#indicator-chart>
- 25 Bhattacharya P, John D, Mukherjee N, *et al.* Estimation of non-health gross domestic product (NHGDP) loss due to COVID-19 deaths in West Bengal, India. *Dryad Digital Depository* 2023.
- 26 Wang H, Paulson KR, Pease SA, *et al.* Estimating excess mortality due to the COVID-19 pandemic: a systematic analysis of COVID-19-related mortality, 2020-21. *Lancet* 2022;399:1513-36.
- 27 World Health Organisation. Global excess deaths associated with COVID-19 (modelled estimates). 2022. Available: <https://www.who.int/data/sets/global-excess-deaths-associated-with-covid-19-modelled-estimates>
- 28 Sharma M. Centre questions estimate model after WHO claims 4.7 million excess covid deaths in India [India Today]. 2022. Available: https://www.indiatoday.in/coronavirus-outbreak/story/govt-questions-estimate-model-who-excess-covid-deaths-india-1945944-2022-05-05?fbclid=IwAR1IXyMQRUNedqC2exir7QI_nBSuLsQJwORAJH1Xx3nn04BwKj1MTPU_GM
- 29 Banaji M. Making sense of COVID-19 mortality estimates for India [The India Forum]. 2022. Available: https://www.theindiaforum.in/article/covid-mortality-india?fbclid=IwAR2UiwHBb0kz0JE_pB3Mp9W4-vT7arBXRkuRH_gM9swjG54H93_smM_VeA
- 30 Kirigia JM, Muthuri RDK. Productivity losses associated with tuberculosis deaths in the World Health Organization African region. *Infect Dis Poverty* 2016;5:43.
- 31 Kirigia JM, Muthuri RNDK. The fiscal value of human lives lost from Coronavirus disease (COVID-19) in China. *BMC Res Notes* 2020;13:198.
- 32 World Bank. West Bengal: poverty, growth and inequality. 2017. Available: <https://documents1.worldbank.org/curated/en/315791504252302097/pdf/119344-BRI-P157572-West-Bengal-Poverty.pdf>
- 33 Husereau D, Drummond M, Augustovski F, *et al.* Consolidated health economic evaluation reporting standards 2022. *BMC Med* 2022;20:23.
- 34 Ramani S. Excess deaths in West Bengal 11 times official COVID-19 tally [The Hindu]. 2021. Available: <https://www.thehindu.com/news/national/other-states/excess-deaths-in-west-bengal-11-times-official-covid-19-tally/article61437729.ece>
- 35 Sinha A. Over 90% Covid deaths went unreported? Why the WHO data RAISES questions [The Indian Express]. 2022. Available: <https://indianexpress.com/article/india/over-90-deaths-went-unreported-why-who-data-raises-questions-7903417/?fbclid=IwAR30Xh-AwmoqsZvDCiBA8JyTfYhmcDQUImnm3xAUTAARgQ3QWI-ic-ow>
- 36 Goel I, Sharma S, Kashiramka S. Effects of the COVID-19 pandemic in India: an analysis of policy and technological interventions. *Health Policy Technol* 2021;10:151-64.
- 37 Covid-19: spread. COVID-19/FACTSHEET [Times of India]. 2022. Available: <https://timesofindia.indiatimes.com/coronavirus/data/covid-19-spread>
- 38 Singh P, Pattanaik F. Unfolding unpaid domestic work in India: women's constraints, choices, and career. *Palgrave Commun* 2020;6.
- 39 Jin H, Wang H, Li X, *et al.* Economic burden of COVID-19, China, January-March, 2020: a cost-of-illness study. *Bull World Health Organ* 2021;99:112-24.
- 40 Ibn-Mohammed T, Mustapha KB, Godsell J, *et al.* A critical analysis of the impacts of COVID-19 on the global economy and ecosystems and opportunities for circular economy strategies. *Resour Conserv Recycl* 2021;164:105169.
- 41 Tandon A, Roubal T, McDonald L, *et al.* *Economic Impact of COVID-19: Implications for Health Financing in Asia and Pacific*. 2020.
- 42 Ataguba JE. COVID-19 pandemic, a war to be won: understanding its economic implications for Africa. *Appl Health Econ Health Policy* 2020;18:325-8.
- 43 Ghaffari Darab M, Keshavarz K, Sadeghi E, *et al.* The economic burden of coronavirus disease 2019 (COVID-19): evidence from Iran. *BMC Health Serv Res* 2021;21:132.
- 44 Kolbin AS, Belousov DY, Gomon YuM, *et al.* Socio-economic burden of COVID-19 in the Russian Federation. *GCP* 2020;35-44.
- 45 Álvarez-Del Río B, Sánchez-de Prada L, Álvaro-Meca A, *et al.* Economic burden of the 2020 COVID-19 hospitalizations in Spain. *JAMA Netw Open* 2023;6:e2250960.
- 46 Janzen B, Radulescu D. Electricity use as a real-time indicator of the economic burden of the COVID-19-related lockdown: evidence from Switzerland. *CESifo Econ Stud* 2020;66:303-21.
- 47 Chen S, Prettnner K, Kuhn M, *et al.* The economic burden of COVID-19 in the United States: estimates and projections under an infection-based herd immunity approach. *J Econ Ageing* 2021;20:100328.
- 48 Oberndorfer M, Dorner TE, Brunnmayr M, *et al.* Health-related and socio-economic burden of the COVID-19 pandemic in Vienna. *Health Soc Care Community* 2022;30:1550-61.

Supplementary 1: CHEERS2022Checklist

	Item	GuidanceforReporting	Reported insection
TITLE			
Title	1	Identify the study as an economic evaluation and specify the interventions being compared.	Page 1, Lines 1 &2
ABSTRACT			
Abstract	2	Provide a structured summary that highlights context, key methods, results and alternative analyses.	Page 2, Lines 55-67
INTRODUCTION			
Background and objectives	3	Give the context for the study, the study question and its practical relevance for decision making in policy or practice.	Page 3-4, Lines 86-132
METHODS			
Health economic analysis plan	4	Indicate whether a health economic analysis plan was developed and where available.	Page 6, Lines 176-180
Study population	5	Describe characteristics of the study population (such as age range, demographics, socioeconomic, or clinical characteristics).	Page 5, Line 145-146
Setting and location	6	Provide relevant contextual information that may influence findings.	Page 5, 167-170
Comparators	7	Describe the interventions or strategies being compared and why chosen.	NA
Perspective	8	State the perspective(s) adopted by the study and why chosen.	Page 4, 134-141
Time horizon	9	State the time horizon for the study and why appropriate.	Page 4, 125-129; Page 5, Line 160
Discount rate	10	Report the discount rate(s) and reason chosen.	Page 6, Table 1
Selection of outcomes	11	Describe what outcomes were used as the measure(s) of benefit(s) and harm(s).	NA
Measurement of outcomes	12	Describe how outcomes used to capture benefit(s) and harm(s) were measured.	NA
Valuation of outcomes	13	Describe the population and methods used to measure and value outcomes.	Pages 4-6, Lines 134-171
Measurement and valuation of resources and costs	14	Describe how costs were evaluated.	Page 5, Line 148
Currency, price date, and conversion	15	Report the dates of the estimated resource quantities and unit costs, plus the currency and year of conversion.	Page 5, Line 170
Rationale and description of model	16	If modelling is used, describe in detail and why used. Report if the model is publicly available and where it can be accessed.	NA
Analytics and assumptions	17	Describe any methods for analysing or statistically transforming data, any extrapolation methods, and approaches for validating any model used.	Page 5-6, 160-171
Characterizing heterogeneity	18	Describe any methods used for estimating how the results of the study vary for sub-groups.	Page 5, 164-171
Characterizing distributional effects	19	Describe how impacts are distributed across different individuals or adjustments made to reflect priority populations.	Page 5, 162-164
Characterizing uncertainty	20	Describe methods to characterize any sources of uncertainty in the analysis.	Page 5, 166-168
Approach to engagement with patients and others affected by the study	21	Describe any approaches to engage patients or service recipients, the general public, communities, or stakeholders (e.g., clinicians or payers) in the design of the study.	NA
RESULTS			
Study parameters	22	Report all analytic inputs (e.g., values, ranges, references) including uncertainty or distributional assumptions.	Page 6, Table 1
Summary of main results	23	Report the mean values for the main categories of costs and outcomes of interest and summarise them in the most appropriate overall measure.	Page 7, Table 2
Effect of uncertainty	24	Describe how uncertainty about analytic judgments, inputs, or projections affect findings. Report the effect of choice of discount rate and time horizon, if applicable.	Pages 7-8, Lines 197-212
Effect of engagement with patient and others affected by the study	25	Report on any difference patient/service recipient, general public, community, or stakeholder involvement made to the approach or findings of the study	NA
DISCUSSION			
Study findings, limitations, generalizability, and current knowledge	26	Report key findings, limitations, ethical or equity considerations not captured, and how these could impact patients, policy, or practice.	Pages 8-11, Lines 217-303
OTHER RELEVANT INFORMATION			
Source of funding	27	Describe how the study was funded and any role of the funder in the identification, design, conduct, and reporting of the analysis	Page 12, Line 324
Conflicts of interest	28	Report authors conflicts of interest according to journal or International Committee of Medical Journal Editors requirements.	Page 12, Line 325-326

Husereau D, Drummond M, Augustovski F, de Bekker-Grob E, Briggs AH, Carswell C, Caulley L, Chaiyakunapruk N, Greenberg D, Loder E, Mauskopf J, Mullins CD, Petrou S, Pwu RF, Staniszewska S; CHEERS 2022 ISPOR Good Research Practices Task Force. Consolidated Health Economic Evaluation Reporting Standards 2022 (CHEERS 2022) Statement: Updated Reporting Guidance for

HealthEconomic Evaluations.BMJ.2022;376:e067975.

The checklist is Open Access distributed in accordance with the terms of the Creative Commons Attribution (CC BY 4.0) license, which permits others to distribute, remix, adapt and build upon this work, for commercial use, provided the original work is properly cited. See:<http://creativecommons.org/licenses/by/4.0/>.