

PEER REVIEW HISTORY

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ARTICLE DETAILS

TITLE (PROVISIONAL)	Are COVID-19 age-mortality curves for 2020 flatter in developing countries? Evidence from a cross-sectional observational study of population-level official death counts and excess deaths estimates.
AUTHORS	Demombynes, Gabriel; de Walque, Damien; Gubbins, Paul; Urdinola, Piedad; Veillard, Jeremy

VERSION 1 – REVIEW

REVIEWER	Sacco, Nicolas Penn State Social Science Research Institute, Sociology
REVIEW RETURNED	15-Apr-2022

GENERAL COMMENTS	<p>I recommend this very well-crafted paper for publication with two minor revisions.</p> <p>First, the literature cited in the Discussion section should also be addressed in the Intro. From my point of view, the main problem of this version of the paper is the literature review section needs to be expanded since part of this research topic is discussed with a footnote condensing eight articles from the literature, for example. The discussion should be developed, including other references, such as Verdery, A. (2020).</p> <p>Second, about the data. The authors mention a Github repository for replication. I would like to have access to that if the authors agree to expand further observations. Still, I don't see any pressures issues with data or results, except that the underreporting of deaths in official counts must be mentioned. We don't know about this in Latin American countries. It might not matter much to the final results but needs to be explicit as a limitation because the authors used it as a proxy for the intensity of the pandemic. Some countries have underreported historical deaths, which probably didn't change with the pandemic. Therefore the trends won't change, but maybe the levels.</p> <p>To conclude, taking into account previous observations. Making some changes to the lit review could set the research in a broader dialogue with the current literature about COVID deaths. Authors could explicitly mention if their results confirm new evidence about the age trends for COVID deaths, what are the public policy implications for this, or if these results confirm previous research findings. In this case, the discussion should emphasize comparing with conclusions of the prior studies addressed in the literature and explaining data needs for further inquiry.</p>
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REVIEWER	Basellini, Ugofilippo Max-Planck-Institute for Demographic Research
REVIEW RETURNED	21-Apr-2022

GENERAL COMMENTS	<p>This manuscript investigates the age-pattern of COVID-19 mortality for a broad set of countries in 2020. Both official COVID-19 deaths and excess deaths are employed in the analysis. The authors find that middle-income countries experienced a flatter age-specific mortality curve than high-income countries, which resulted in a greater share of official and excess deaths at younger ages. Importantly, this difference is only partially attributable to different population age structures. The analysis is restricted to 2020 as vaccination uptake in 2021 may have changed such mortality age-patterns.</p> <p>The study is clearly important, well-motivated and a relevant contribution to the COVID-19 mortality literature. I very much appreciated the investigation of both COVID-19 deaths and excess mortality, which jointly provide a more comprehensive view on the effect of the pandemic. The manuscript is clear and well-structured, and I only have a series of comments and suggestions for the authors that could be considered in the revision of their work.</p> <ul style="list-style-type: none"> - Strengths and limitations of the study (box). The third bullet point is rather long, perhaps it could be broken down into two (or the sentence could be shortened). I would suggest the authors also add another strength coming from their analysis, namely that the difference in the mortality age-profile is only partially attributable to different population age structures. Finally, I appreciated that you explicitly mentioned that the study does not cover low-income countries, and I would suggest including this information also in your Discussion section. - Abstract, line 21: "A higher share of pandemic-related deaths in 2020 were". I would replace the verb "were" with "occurred". - Excess mortality calculations, p.4: I very much appreciated that you employed a methodology that includes a time trend in the computation of baseline mortality. I suggest the authors cite two relevant works that have investigated the sensitivity of excess mortality estimates to different methodologies: Nepomuceno et al. 2022; Scholey 2021. Both works highlighted the potential shortcoming of not including a trend in the computation of the baseline. - Slope calculation, p.5-6: rather than fitting a line using a linear regression model, a more appropriate approach would be working in a Poisson framework for death counts with exposures as an offset (Brillinger 1986). You could run a Poisson regression with the same covariates of your OLS model, but using deaths as response variable and exposures as offset. With this approach, you could use all age groups, since Poisson regression would give greater weights at older ages (where more deaths occur). Moreover, you could change the procedure described in footnote 2 (coding with 0.001 cases where excess deaths are zero or negative) by assigning a weight of zero to such cases. Finally, you could mention that you are basically fitting a Gompertz (1825) model to the data. - Slope calculation, p.5 (line 49) and p.6 (line 34): "percent rate of increase in probability of death". This is marginally incorrect: the beta parameter captures the rate of increase in the mortality rate, and not in the probability of death.
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	<p>- Results, p.8, lines 36-39: “These patterns indicate that for these country-age group combinations, the number of deaths averted due to the pandemic exceeds the sum of direct and indirect COVID-19 deaths.” Perhaps I am mistaken, but I think this sentence is incorrect. You write that official COVID-19 deaths are higher than excess deaths (line 32). According to the formula in page 5, line 28, (net excess deaths - direct COVID-19 deaths) is smaller than 0. This means that (Indirect COVID-19 deaths - averted deaths) is smaller than 0 too, i.e., that averted deaths are greater than indirect COVID-19 deaths only (and not of the sum of direct and indirect deaths). Can you please check and eventually correct/rephrase this?</p> <p>- Results, p. 9: Figure 6a should be Figure 6, while Figure 6b should be Figure 7</p> <p>- References: References 6 and 17 are the same and repeated, while References 2 and 3 could also be collapsed into a single one (the latter being the pre-print of the former).</p> <p>- Figure 4: why didn't you use the log-scale as in Figure 5? I think this would enhance readability showing the linear increase over ages, rather than the exponential one (for negative values, you could simply revert the positive scale)</p> <p>- Data Availability: it would be useful to add information on when you extracted data from COVERAGE database and STMF, as these databases are continuously updated.</p> <p>References</p> <p>Brillinger, D. R. (1986). A biometrics invited paper with discussion: The natural variability of vital rates and associated statistics. <i>Biometrics</i>, 42(4):693–734.</p> <p>Gompertz, B. (1825). On the nature of the function expressive of the law of human mortality, and on a new mode of determining the value of life contingencies. <i>Philosophical Transactions of the Royal Society of London</i>, 115:513–583.</p> <p>Nepomuceno, M.R., Klimkin, I., Jdanov, D.A., Alustiza-Galarza, A. and Shkolnikov, V.M. (2022). Sensitivity Analysis of Excess Mortality due to the COVID-19 Pandemic. <i>Population and Development Review</i>. https://doi.org/10.1111/padr.12475</p> <p>Schöley, J. (2021). Robustness and bias of European excess death estimates in 2020 under varying model specifications. <i>MedRxiv</i>. https://doi.org/10.1101/2021.06.04.21258353</p>
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VERSION 1 – AUTHOR RESPONSE

Reviewer Reports:

Reviewer: 1

Dr. Nicolas Sacco, Penn State Social Science Research Institute

Comments to the Author:

I recommend this very well-crafted paper for publication with two minor revisions.

Thank you very much for your kind comments

First, the literature cited in the Discussion section should also be addressed in the Intro. From my point of view, the main problem of this version of the paper is the literature review section needs to be expanded since part of this research topic is discussed with a footnote condensing eight articles from the literature, for example. The discussion should be developed, including other references, such as Verdery, A. (2020).

Response: Thank you very much for this suggestion. We have expanded and added the literature review in the introduction and have added the suggested reference.

Second, about the data. The authors mention a Github repository for replication. I would like to have access to that if the authors agree to expand further observations. Still, I don't see any pressures issues with data or results, except that the underreporting of deaths in official counts must be mentioned. We don't know about this in Latin American countries. It might not matter much to the final results but needs to be explicit as a limitation because the authors used it as a proxy for the intensity of the pandemic. Some countries have underreported historical deaths, which probably didn't change with the pandemic. Therefore the trends won't change, but maybe the levels.

Response: We will make the Github repository for replication available upon publication. Please also note that our online appendix describes how the countries were selected and what the inclusion criteria were. We have now summarized this information in the Data sources subsection of the Methods, including the data at which the database were accessed.

Please note that for the COVerAGE database, since our initial manuscript submission, 16 countries have been added (Bosnia and Herzegovina; Bulgaria; Cameroon; Georgia; Guatemala; Kazakhstan; Latvia; Lithuania; Mauritius; Nicaragua; North Macedonia; Oman; Qatar; Serbia; Sierra Leone and United Arab Emirates) to the base, while three (Iceland, South Africa, Taiwan) have been removed. In order to have a study as complete and as up-to-date as possible, we decided to go with the most recent version of the databases.

Finally, thank you for the useful point about the possible underreporting of all-causes mortality. We have added this as a study limitation in the discussion:

“Finally, we acknowledge that, even as we used excess mortality measures to address the concern of under-reporting of official COVID-19 deaths, all causes mortality itself could also be underreported in some countries and that the extent of underreporting might vary across countries. This would however affect our analysis only to the extent that the underreporting of all causes mortality was affected by the COVID pandemic.”

To conclude, taking into account previous observations. Making some changes to the lit review could set the research in a broader dialogue with the current literature about COVID deaths. Authors could explicitly mention if their results confirm new evidence about the age trends for COVID deaths, what are the public policy implications for this, or if these results confirm previous research findings. In this case, the discussion should emphasize comparing with conclusions of the prior studies addressed in the literature and explaining data needs for further inquiry.

Response: Thank you. We have revised the introduction and especially the literature review, as suggested and detailed above. We have also added references to the COVID mortality estimates newly released by the World Health Organization. In the methods section, however, we have stressed that our study doesn't use modelled data.

Reviewer: 2

Dr. Ugofilippo Basellini, Max-Planck-Institute for Demographic Research

Comments to the Author:

This manuscript investigates the age-pattern of COVID-19 mortality for a broad set of countries in 2020. Both official COVID-19 deaths and excess deaths are employed in the analysis. The authors find that middle-income countries experienced a flatter age-specific mortality curve than high-income countries, which resulted in a greater share of official and excess deaths at younger ages. Importantly, this difference is only partially attributable to different population age structures. The analysis is restricted to 2020 as vaccination uptake in 2021 may have changed such mortality age-patterns.

The study is clearly important, well-motivated and a relevant contribution to the COVID-19 mortality literature. I very much appreciated the investigation of both COVID-19 deaths and excess mortality, which jointly provide a more comprehensive view on the effect of the pandemic. The manuscript is clear and well-structured, and I only have a series of comments and suggestions for the authors that could be considered in the revision of their work.

Thank you very much for your kind comments

- Strengths and limitations of the study (box). The third bullet point is rather long, perhaps it could be broken down into two (or the sentence could be shortened). I would suggest the authors also add another strength coming from their analysis, namely that the difference in the mortality age-profile is only partially attributable to different population age structures. Finally, I appreciated that you explicitly mentioned that the study does not cover low-income countries, and I would suggest including this information also in your Discussion section.

Response: We have shortened the bullet points in this section, removing, as suggested by the editor, any reference to the novelty or the results and focusing on the methods. We have also added one methodological bullet point (the 3rd one) following your suggestion. In the discussion, we have also added, as a limitation, the fact that the database we are using only includes few low-income countries.

- Abstract, line 21: "A higher share of pandemic-related deaths in 2020 were". I would replace the verb "were" with "occurred".

Response: Thank you. We made the suggested change.

- Excess mortality calculations, p.4: I very much appreciated that you employed a methodology that includes a time trend in the computation of baseline mortality. I suggest the authors cite two relevant works that have investigated the sensitivity of excess mortality estimates to different methodologies: Nepomuceno et al. 2022; Scholey 2021. Both works highlighted the potential shortcoming of not including a trend in the computation of the baseline.

Response: Thank you for this suggestion. We have added the two suggested citations.

- Slope calculation, p.5-6: rather than fitting a line using a linear regression model, a more appropriate approach would be working in a Poisson framework for death counts with exposures as an offset (Brillinger 1986). You could run a Poisson regression with the same covariates of your OLS model, but using deaths as response variable and exposures as offset. With this approach, you could use all

age groups, since Poisson regression would give greater weights at older ages (where more deaths occur). Moreover, you could change the procedure described in footnote 2 (coding with 0.001 cases where excess deaths are zero or negative) by assigning a weight of zero to such cases. Finally, you could mention that you are basically fitting a Gompertz (1825) model to the data.

Response: Thank you for this suggestion which we have followed (see Methods section – Slope calculation) for Figures 6 and 7.

- Slope calculation, p.5 (line 49) and p.6 (line 34): “percent rate of increase in probability of death”. This is marginally incorrect: the beta parameter captures the rate of increase in the mortality rate, and not in the probability of death.

Response: Thank you. We have made the suggested corrections.

- Results, p.8, lines 36-39: “These patterns indicate that for these country-age group combinations, the number of deaths averted due to the pandemic exceeds the sum of direct and indirect COVID-19 deaths.” Perhaps I am mistaken, but I think this sentence is incorrect. You write that official COVID-19 deaths are higher than excess deaths (line 32). According to the formula in page 5, line 28, (net excess deaths - direct COVID-19 deaths) is smaller than 0. This means that (Indirect COVID-19 deaths - averted deaths) is smaller than 0 too, i.e., that averted deaths are greater than indirect COVID-19 deaths only (and not of the sum of direct and indirect deaths). Can you please check and eventually correct/rephrase this?

Response: Thank you for pointing this out. We verified and you are right. We have made the correction.

- Results, p. 9: Figure 6a should be Figure 6, while Figure 6b should be Figure 7

Response: Thank you for pointing this out. We made the correction.

- References: References 6 and 17 are the same and repeated, while References 2 and 3 could also be collapsed into a single one (the latter being the pre-print of the former).

Response: Thank you for pointing this out. We made the correction.

- Figure 4: why didn't you use the log-scale as in Figure 5? I think this would enhance readability showing the linear increase over ages, rather than the exponential one (for negative values, you could simply revert the positive scale)

Response: Thank you for this suggestion, which we have followed.

- Data Availability: it would be useful to add information on when you extracted data from COVERAGE database and STMF, as these databases are continuously updated.

Response: Thank you for this suggestion. We have added the date of data extraction both in the Data Sources subsection in the Methods section and in the Online Appendix/Data availability.

References

Brillinger, D. R. (1986). A biometrics invited paper with discussion: The natural variability of vital rates and associated statistics. *Biometrics*, 42(4):693–734.

Gompertz, B. (1825). On the nature of the function expressive of the law of human mortality, and on a new mode of determining the value of life contingencies. *Philosophical Transactions of the Royal Society of London*, 115:513–583.

Nepomuceno, M.R., Klimkin, I., Jdanov, D.A., Alustiza-Galarza, A. and Shkolnikov, V.M. (2022). Sensitivity Analysis of Excess Mortality due to the COVID-19 Pandemic. *Population and Development Review*.

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Schöley, J. (2021). Robustness and bias of European excess death estimates in 2020 under varying model specifications. *MedRxiv*.

<https://nam11.safelinks.protection.outlook.com/?url=https%3A%2F%2Fdoi.org%2F10.1101%2F2021.06.04.21258353&data=05%7C01%7Cddewalque%40worldbank.org%7C37a20afd13c4402e409a08da238616af%7C31a2fec0266b4c67b56e2796d8f59c36%7C0%7C0%7C637861356526991911%7CUnknown%7CTWFpbGZsb3d8eyJWljojMC4wLjAwMDAiLCJQIjoiV2luMzliLCJBTiI6IjEhaWwiLCJXVCi6Mn0%3D%7C3000%7C%7C%7C&sdata=E1d5ffb4qEk5KIJY9x5xQcvnYxzYBBjSZIdO%2B797K38%3D&reserved=0>

VERSION 2 – REVIEW

REVIEWER	Sacco, Nicolas Penn State Social Science Research Institute, Sociology
REVIEW RETURNED	11-Jul-2022

GENERAL COMMENTS	No comments.
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REVIEWER	Basellini, Ugofilippo Max-Planck-Institute for Demographic Research
REVIEW RETURNED	24-Jun-2022

GENERAL COMMENTS	I would like to thank the authors for their careful revision of the manuscript. I do not have any additional comments (other than correcting the "extend" typo, which should be "extent", in the Strength and limitations box), and I recommend this paper for publication without further revisions.
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VERSION 2 – AUTHOR RESPONSE

Reviewer: 2

Dr. Ugofilippo Basellini, Max-Planck-Institute for Demographic Research

Comments to the Author:

I would like to thank the authors for their careful revision of the manuscript.

I do not have any additional comments (other than correcting the "extend" typo, which should be "extent", in the Strength and limitations box), and I recommend this paper for publication without further revisions.

Response: Thank you very much. We have corrected the typo noted in the Strength and limitations box.

Reviewer: 1

Dr. Nicolas Sacco, Penn State Social Science Research Institute

Comments to the Author:

No comments.

Response: Thank you very much.

Reviewer: 2

Competing interests of Reviewer: I declare no competing interests

Reviewer: 1

Competing interests of Reviewer: -