Rev. cient. cienc. salud. 2024; 6: e6155
Doi: 10.53732/rccsalud/2024.e6155

Artículo original/Original Article

The impact of the COVID-19 pandemic on all-cause mortality in Paraguay: 2020 - 2022

El Impacto de la pandemia de COVID-19 en la mortalidad por todas las causas en Paraguay: 2020 – 2022

Andreas Schneider[1]

[1]Autor independiente

Cómo citar/How cite:
Schneider A. The impact of the COVID-19 pandemic on all-cause mortality in Paraguay: 2020 – 2022. Rev. cient. cienc. salud. 2024; 6:e6155. 10.53732/rccsalud/2024.e6155

Fecha de recepción:
14/09/2024
Fecha de revisión:
10/10/2024
Fecha de aceptación:
30/11/2024

Autor correspondiente:
Andreas Schneider
e-mail:
schneiderconsultingpy@gmail.com

Editor responsable:
Margarita Samudio
Universidad del Pacífico.
Dirección de Investigación.
Asunción, Paraguay
e-mail:
margarita.samudio@upacifico.edu.py

ABSTRACT

Introduction. Few studies examined the impact of the COVID-19 pandemic on all-cause mortality in Paraguay. **Objective.** Quantifying the impact of the coronavirus pandemic on all-cause mortality in Paraguay between 2020 and 2022. **Material and Method.** A custom Bayesian structural time series analysis with autoregressive (AR1) and seasonal components was used to predict counterfactual counts of all-cause mortality and compute excess death. **Results.** Paraguay reported 122,360 all-cause deaths between 2020-22, compared to an expected 88,988 deaths had the pandemic not occurred, a relative excess mortality of 38%. It is likely that Paraguay undercounted COVID-19 related deaths in the first year of the pandemic. **Conclusion.** The results presented in this paper extended the knowledge on the impact of COVID-19 on all-cause mortality in the context of Paraguay, being a valuable decision tool for public policy makers. Overall, Paraguay presented good quality of all-cause mortality data, however, high excess mortality should raise concern. Further research is needed to shed light on gender-specific, age-structural or geographical differences and to further identify inequalities.

Palabras clave: all-cause mortality; excess mortality; Covid-19; Paraguay

RESUMEN

Introducción. Pocos estudios han examinado el impacto de la pandemia de COVID-19 en la mortalidad por todas las causas en Paraguay. **Objetivo.** Cuantificar el impacto de la pandemia por coronavirus en la mortalidad por todas las causas en Paraguay entre 2020 y 2022. **Materiales y Método.** Se utilizó un análisis de series temporales estructurales Bayesiana personalizado con componentes autorregresivos (AR1) y estacionales para predecir recuentos contrafactuales de mortalidad por todas las causas y calcular el exceso de mortalidad. **Resultados.** Paraguay reportó 122.360 muertes por todas las causas entre 2020-22, en comparación con las 88.988 muertes esperadas si no hubiera ocurrido la pandemia, un exceso de mortalidad relativa del 38%. Es probable que Paraguay subestimó las muertes relacionadas con el COVID-19 en el primer año de la pandemia. **Conclusión.** Los resultados presentados en este trabajo ampliaron el conocimiento sobre el impacto del COVID-19 en la mortalidad por todas las causas en el contexto de Paraguay, siendo una valiosa herramienta de decisión para los responsables de las políticas públicas. Sin embargo, son necesarias más investigaciones para arrojar luz sobre las diferencias de género y de estructura etaria.

Keywords: mortalidad por todas las causas; exceso de mortalidad; Covid-19; Paraguay

INTRODUCCIÓN

The global spread of a new SARS-CoV-2 virus has so far caused a worldwide pandemic with more than seven million deaths in around 240 countries[1]. The overall impact of the COVID-19 pandemic on mortality at the population level is of great concern to public health and the reporting of available evidence for public policy is a valuable tool for decision-makers and the general public[2,3], especially in countries and times with limited resources. The sudden emergence of the coronavirus was a major challenge for the healthcare system in many countries, including Paraguay. Schneider, for example, reported a case fatality rate of about 2.5% for Paraguay[4], however, this does not reflect the risk of dying from COVID-19. Not just direct effects, such as the measures imposed by the health authorities to combat the epidemic through vaccination, isolation and the wearing of face masks, have an influence on all-cause mortality. Other critical outcomes are access to hospitals, in particular to primary care, not related to COVID-19 infections. Individual fear of contracting the SARS-CoV-2 virus leaving stay-at-home orders to seek primary care or the fear of encountering overloaded hospital admissions may impact the decision of care seekers and lead to increased deaths from non-COVID-19 causes[5].Therefore, crude deaths counts are not a good indicator of a pandemic burden[6,7]. Measuring the excess of all-cause mortality encompasses direct and indirect effects[5,8,9] and is an important metric in tracking the impact of a pandemic, within and between countries[8], however, estimating excess mortality depends on the baseline model used[10]. Interestingly, the most frequent methods used are regression and simple averages, such as the five-year average[11]; however, simple averages is the least recommended method since it ignores trend and seasonal effects, leading to underestimations of excess mortality[10,12–15]. This study uses advanced statistical methods to quantify the impact of the COVID-19 pandemic in Paraguay between 2020 and 2022.

METHODS

The monthly all-cause deaths count data at population-level for the period 2013 - 2022 were obtained from the Public Ministry of Health through a freedom of information request. The data contained 21 different causes of death without patient information, aggregated according to the International Statistical Classification of Diseases and Related Health Problems, 10th Revision (ICD-10). The national population figures were obtained from the national statistics office (INE) and were based on census data from 2015. As national population figures are only available annually the author first age-standardized the yearly data according to the WHO world population standard and then interpolated the result to obtain monthly population data.

The study took into account several covariates mentioned in the literature, such as cardiovascular disease death rates, diabetes death rates, cerebrovascular death rates, respiratory system death rates, and national daily average temperature[16–18]. The covariates were selected based on the strength of association and availability. COVID-19 data were sourced from the COVID-19 Data Hub[19]. As the focus of this study is on quantifying the impact of the pandemic on all-cause mortality and not on a country comparison, we used leap-year adjusted counts to model excess mortality. Using excess mortality or excess deaths allowed us to estimate additional deaths in a given time period, compared to what we would have expected, and does not depend on how COVID-19 deaths are recorded[6].

In addition, this study also computed undercount factors, that is, the ratio of excess mortality to the officially reported COVID-19 death counts of the same year[20], as well as P-scores(%), which indicates the relative excess mortality (i.e. observed deaths - expected deaths / expected deaths) for the pandemic years under consideration. Larger values indicate increasing levels of excess deaths[3]. Excess mortality estimates, P-scores,

and undercount factors were computed starting from March, 2020 reflecting the official start of the pandemic in Paraguay[21].

The author used counterfactual reasoning[5] to estimate excess death from all-cause mortality data, that is, what would have happened if the pandemic has not occurred. A custom Bayesian Structural time series approach with 5000 Markov chain Monte Carlo (MCMC) simulations was used to train the data on pre-pandemic years until 2018, and then further validated to predict values for 2019. The final model included autoregressive (AR1) and seasonal components, to predict estimates of counterfactuals with 95% Bayesian credible intervals for the COVID-19 pandemic period from March, 2020 to December, 2022.

All analyses were performed using R statistical software with R version 4.4.1[22].

RESULTS

The overall death rate for Paraguay was 4.76 per 1000 population. All-cause mortality was already showing a slow upward trend up to 2019 (Figure 1). Paraguay reported 122,360 deaths from all causes between 2020 and 2022 (2020: 29,673; 2021: 53,073; 2022: 39,614), compared to an expected 88,988 (Bayes 95% CI: 84,044 to 93,627) had the pandemic not occurred. This counterfactual translates to an increase of 33,372 excess in all-cause deaths (95% CI: 28,733 to 38,316), a relative difference of 38% (95% CI: 31%; 46%). Interestingly, the P-score (%) was higher in 2022, suggesting higher COVID-19 prevalence, which can also be observed visually in figure 1.

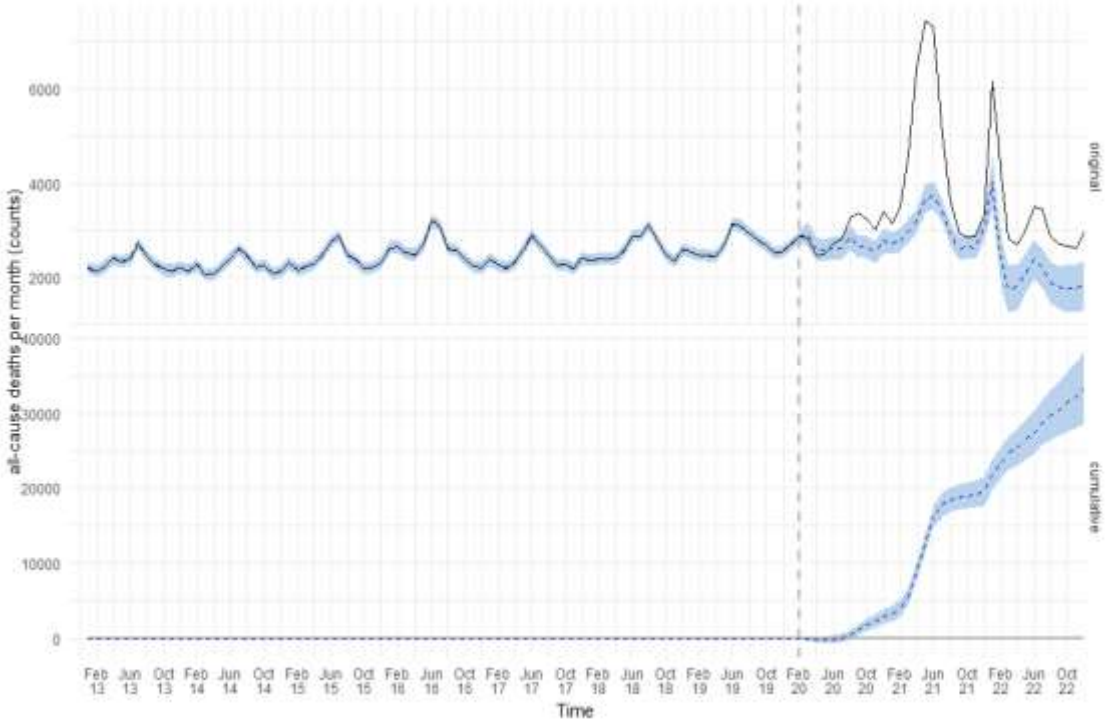

Figure 1. Monthly all-cause mortality predictions (dashed line) vs. fitted counts (black line). The Shadowed area indicates 95% Bayesian credible intervals. The vertical line indicates the start of the pandemic. The below plot shows the cumulative excess deaths.

Paraguay showed a relative accurate reporting of COVID-19 related death; however, it is likely that Paraguay undercounted COVID-19 deaths during the first year of the pandemic as indicated by the undercount factor of 1.2 (r = 0.7). Excess deaths have more than doubled when comparing 2021 to 2020. Nevertheless, in 2022 the undercount factor decreased to 0.7.

The following table (Table 1) gives an overview and summary statistics for excess deaths, P-score (%), and undercount factor for the time under consideration.

Table 1. Summery statistics for excess death, P-score (%), and undercount factor

Year	Expected	Observed	Excess	P-score (%)	Cumulative Covid-death	Undercount factor
2,020	26,868	29,673	2,805	10.4	2,292	1.2
2,021	36,360	53,073	16,713	46	16,624	1
2,022	25,760	39,614	13,854	53.8	19,688	0.7

Decomposing the time series (Figure 2), the seasonal component (middle-panel) indicated a clear seasonal pattern, while the top-panel shows the autoregressive (AR1) term used in the final model.

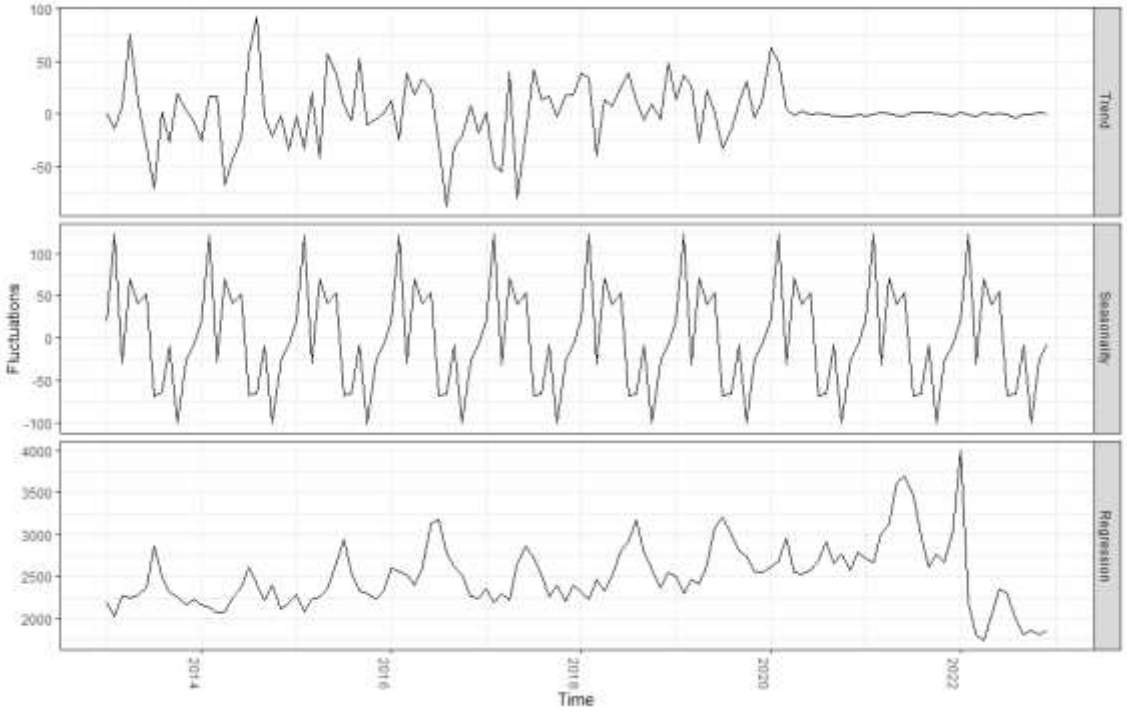

Figure 2. Components of the final model with Trend (top-panel), Seasonal (middle-panel) and Regression (bottom-panel) component and their respective fluctuations.

Looking further at the seasonal component, figure 3 indicates that all-cause mortality increased with decreasing temperature during winter (April - July) with a clear peak in June.

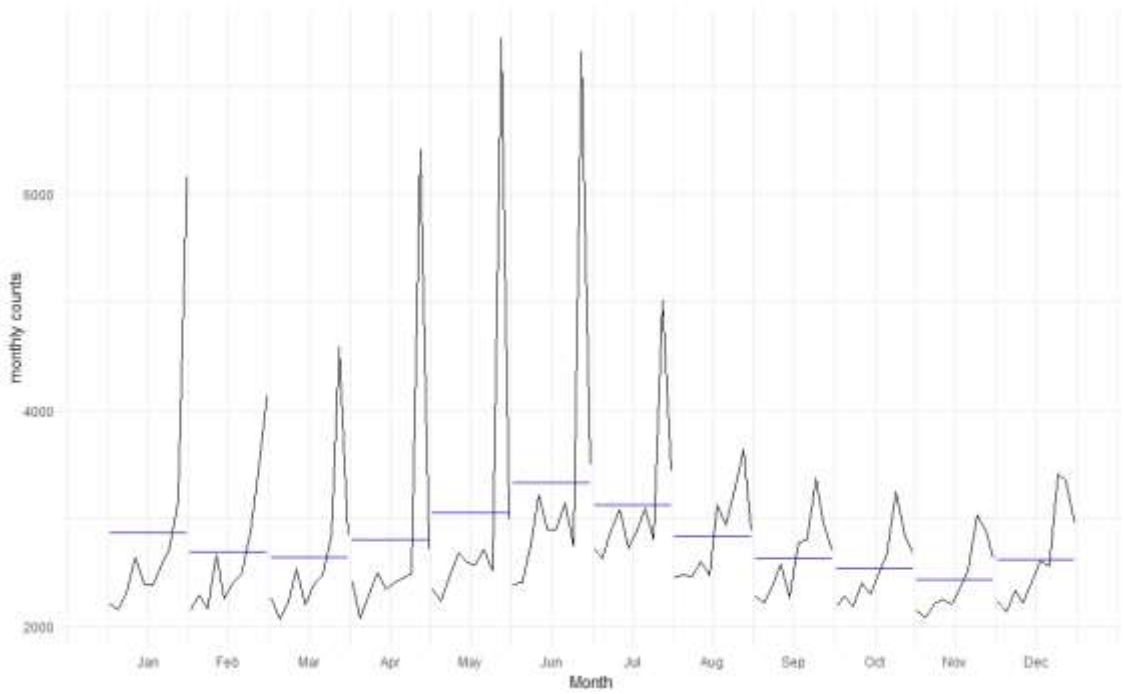

Figure 3. Seasonal subseries of monthly all-cause deaths. Horizontal lines indicate monthly averages

DISCUSSION

This study uses Bayesian Structural time series analysis to quantify excess mortality in times of the COVID-19 pandemic in Paraguay. The country has excess death in all three pandemic years under consideration and likely undercounting COVID-19 related deaths in the first year, probably due to a lack of testing capacities, reporting challenges, awareness, or a general reduction or access to health care services, and, in particular primary health care[3,23,24]. A notable drop in the undercount factor in 2022 could be due to not only confirmed but also suspected Covid cases, as well as deaths from other causes such as respiratory or cardiovascular diseases, especially with the sometimes rapidly falling temperatures during the winter months. A slight upward trend in all-cause mortality can already be observed before the country was hit by the COVID-19 pandemic, which may indicate a slow detorization of the healthcare system in general.

A few studies cover countries on the South American continent, including Paraguay[20,25,26]. At a regional level, it is known from the literature that countries such as Peru, Bolivia and Brazil have high excess mortality rates[20,26]. Although these studies are not directly comparable, as they use different methods, e.g., linear regression or over dispersed Poisson regression models[14], for estimating the expected counterfactuals and different time periods, they are generally consistent with the results of this study. Wang et al[26], for example, estimate 22,500 excess deaths for the period 2020-21, using a weighted ensemble technique of six different models, while Karlinsky and Kobak[20] estimate 9,600 excess deaths using a linear regression with data from March, 2020 until the end of May, 2021, and Schumacher et.al[25] estimate about 1,000 excess deaths for 2020, and about 15,000 for 2021.

On a regional level undercount factors are, on average, between 1.44 (2020), 1.27 (2021), and 1.34 (2022), which, in general, indicates good quality of all-cause mortality data for Paraguay[3] (see Table 1). Excess mortality, in an international context of a cross-national study of 49 Western countries, reached, on average, a P-score of 11.4% in 2020, 13.8% in 2021 and 8.8% in 2022[27], therefore, figures for Paraguay should be a cause for concern for the national authorities.

While the results presented in this paper extend the knowledge on the impact of COVID-19 on all-cause mortality in the context of Paraguay, the study is not without limitations. The author acknowledges that a gender and age-specific analysis would shed more light on the overall impact of the pandemic and might identify inequalities among different population groups. While variations in estimating excess mortality are small between weekly and monthly data, it might be better to use weekly data[10], as a faster way to identify patterns and changes of a pandemic outbreak. Furthermore, deaths from the COVID-19 pandemic itself are not accounted for in this study. These limitations should guide further research on quantifying the impact of COVID-19 on all-cause mortality.

To the best of the author's knowledge this is the first national study to evaluate the impact of COVID-19 on all-cause mortality covering three years of the pandemic using advanced statistical methods.

Author's Statement: The author approves the final version of the article.

Conflict of interest: The author has no conflict of interest to declare.

Funding: This study was supported by the National Council for Science and Technology through the National Incentive Program for Researchers (CONACYT-PRONII).

BIBLIOGRAPHIC REFERENCES

1. World Health Organization. WHO COVID-19 dashboard. https://data.who.int/dashboards/covid19/cases
2. Head B. Toward More "Evidence-Informed" Policy Making? Public Administration Review. 2024. https://doi.org/10.1111/puar.12475
3. Msemburi W, Karlinsky A, Knutson V, Aleshin-Guendel S, Chatterji S, Wakefield J. The WHO estimates of excess mortality associated with the COVID-19 pandemic. Nature. 2023;613(7942):130–137. https://doi.org/10.1038/s41586-022-05522-2 .
4. Schneider A. El crimen callejero durante el COVID-19: una comparación retrospectiva de dos capitales latinoamericanas. Revista Paraguay desde las Ciencias Sociales. 2024;(14):73–91. https://publicaciones.sociales.uba.ar/index.php/revistaparaguay/article/view/9800
5. Beaney T, Clarke JM, Jain V, Golestaneh AK, Lyons G, Salman D, et al. Excess mortality: the gold standard in measuring the impact of COVID-19 worldwide? JRSM. 2020;113(9):329–334. https://doi.org/10.1177/0141076820956802
6. Krelle H, Barclay C, Tallack C. Understanding excess mortality - The Health Foundation. https://www.health.org.uk/reports-and-analysis/analysis/understanding-excess-mortality
7. Weinberger DM, Chen J, Cohen T, Crawford FW, Mostashari F, Olson D, et al. Estimation of Excess Deaths Associated With the COVID-19 Pandemic in the United States, March to May 2020. JAMA Internal Medicine. 2020;180(10):1336–1344. https://doi.org/10.1001/jamainternmed.2020.3391
8. Islam N. "Excess deaths" is the best metric for tracking the pandemic. BMJ. 2022;376:o285. https://doi.org/10.1136/bmj.o285 .
9. Whittaker C, Walker PGT, Alhaffar M, Hamlet A, Djaafara BA, Ghani A, et al. Under-reporting of deaths limits our understanding of true burden of covid-19. BMJ. 2021;375:n2239. https://doi.org/10.1136/bmj.n2239
10. Nepomuceno MR, Klimkin I, Jdanov DA, Alustiza-Galarza A, Shkolnikov VM. Sensitivity Analysis of Excess Mortality due to the COVID-19 Pandemic. Population and Development Review. 2022;48(2):279–302. https://doi.org/10.1111/padr.12475
11. Modig K, Ahlbom A, Ebeling M. Excess mortality from COVID-19: weekly excess death rates by age and sex for Sweden and its most affected region. European Journal of Public Health. 2021;31(1):17–22. https://doi.org/10.1093/eurpub/ckaa218
12. Ferenci T. Comparing methods to predict baseline mortality for excess mortality calculations. BMC Med Res Methodol. 2023;23(1): 239. https://doi.org/10.1186/s12874-023-02061-w
13. Alicandro G, La Vecchia C, Islam N, Pizzato M. A comprehensive analysis of all-cause and cause-specific excess

deaths in 30 countries during 2020. European Journal of Epidemiology. 2023;38(11): 1153–1164. https://doi.org/10.1007/s10654-023-01044-x

14. Islam N, Shkolnikov VM, Acosta RJ, Klimkin I, Kawachi I, Irizarry RA, et al. Excess deaths associated with covid-19 pandemic in 2020: age and sex disaggregated time series analysis in 29 high income countries. BMJ. 2021;373:n1137. https://doi.org/10.1136/bmj.n1137
15. Hopper NA, Campbell A, Roberts C, Ramsay J, IJpelaar J, Glickman M, et al. A comparison of excess deaths by UK country and region during the first year of the COVID-19 pandemic. European Journal of Public Health. 2024;34(2):411–414. https://doi.org/10.1093/eurpub/ckad144
16. Williamson EJ, Walker AJ, Bhaskaran K, Bacon S, Bates C, Morton CE, et al. Factors associated with COVID-19-related death using OpenSAFELY. Nature. 2020;584(7821):430–436. https://doi.org/10.1038/s41586-020-2521-4
17. Treskova-Schwarzbach M, Haas L, Reda S, Pilic A, Borodova A, Karimi K, et al. Pre-existing health conditions and severe COVID-19 outcomes: an umbrella review approach and meta-analysis of global evidence. BMC Med. 2021;19:212. https://doi.org/10.1186/s12916-021-02058-6
18. Gasparrini A, Guo Y, Hashizume M, Lavigne E, Zanobetti A, Schwartz J, et al. Mortality risk attributable to high and low ambient temperature: a multicountry observational study. The Lancet. 2015;386(9991):369–375. https://doi.org/10.1016/S0140-6736(14)62114-0
19. Guidotti E, Ardia D. COVID-19 Data Hub. Journal of Open-Source Software. 2020;5(51):2376. https://doi.org/10.21105/joss.02376
20. Karlinsky A, Kobak D. Tracking excess mortality across countries during the COVID-19 pandemic with the World Mortality Dataset. Davenport MP, Lipsitch M, Lipsitch M, Simonsen L, Mahmud A (eds.) eLife. 2021;10:e69336. https://doi.org/10.7554/eLife.69336
21. Mazzoleni Insfrán J. Salud Pública en tiempos de COVID-19 en Paraguay, marzo 2020/2021. Re salud publica Parag. 2021;11(1):1–7. https://doi.org/10.18004/rspp.2021.junio.1
22. R Core Team. R: A Language and Environment for Statistical Computing. Vienna, Austria: R Foundation for Statistical Computing; 2024. https://www.R-project.org/
23. Chen YH, Stokes AC, Aschmann HE, Chen R, DeVost S, Kiang MV, et al. Excess natural-cause deaths in California by cause and setting: March 2020 through February 2021. PNAS Nexus. 2022;1(3):1–8. https://doi.org/10.1093/pnasnexus/pgac079
24. Paglino E, Lundberg DJ, Wrigley-Field E, Zhou Z, Wasserman JA, Raquib R, et al. Excess natural-cause mortality in US counties and its association with reported COVID-19 deaths. Proc. Natl. Acad. Sci. 2024;121(6): e2313661121. https://doi.org/10.1073/pnas.2313661121
25. Schumacher AE, Kyu HH, Aali A, Abbafati C, Abbas J, Abbasgholizadeh R, et al. Global age-sex-specific mortality, life expectancy, and population estimates in 204 countries and territories and 811 subnational locations, 1950–2021, and the impact of the COVID-19 pandemic: a comprehensive demographic analysis for the Global Burden of Disease Study 2021. The Lancet. 2024;403(10440):1989–2056. https://doi.org/10.1016/S0140-6736(24)00476-8
26. Wang H, Paulson KR, Pease SA, Watson S, Comfort H, Zheng P, et al. Estimating excess mortality due to the COVID-19 pandemic: a systematic analysis of COVID-19-related mortality, 2020–21. The Lancet. 2022;399(10334):1513–1536. https://doi.org/10.1016/S0140-6736(21)02796-3
27. Mostert S, Hoogland M, Huibers M, Kaspers G. Excess mortality across countries in the Western World since the COVID-19 pandemic: 'Our World in Data' estimates of January 2020 to December 2022. BMJ Public Health. 2024;2(1). https://doi.org/10.1136/bmjph-2023-000282