Estimation of all-cause excess mortality by age-specific mortality patterns of COVID-19 pandemic in Peru in 2020

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30 March 2021

Summary

Background

All-cause excess mortality is a comprehensive measure of the combined direct and indirect effects of COVID-19 on mortality. Estimates are usually derived from Civil Registration and Vital Statistics (CRVS) systems, but these do not include non-registered deaths, which may be affected by changes in vital registration coverage over time.

Methods

We use quasi-Poisson models to estimate excess registered mortality in Peru during the first wave of the COVID-19 pandemic during 2020. We use logistic mixed-effects

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models to estimate the completeness of the new online registration system (SINADEF) at this time.

Findings

We estimate that registered mortality nationally underestimates mortality by 30·1% (95% CI 28·9% - 32·7%). We estimate total all-cause excess mortality during the period of analysis at 142,875 (95% CI 127,163 - 155,739) of which 99,814 (95% CI 85,605 - 110,738) were captured by the vital registration system. Deaths at age 60 and over accounted for 74·9% (95% CI 74·9% - 75·0%) of total excess deaths, while there were fewer deaths than expected in younger age groups. Lima region, on the Pacific coast and including the national capital, accounts for 76,158 (95% CI 72,740 - 79,212) excess deaths, while the regions of Apurimac and Pasco account for less than 300 excess deaths.

Interpretation

Estimating excess mortality in low- and middle-income countries (LMICs) such as Peru must take under-registration of mortality into account. Combining demographic trends with data from administrative registries reduces uncertainty and measurement errors. In countries like Peru, this is likely to produce significantly higher estimates of excess mortality than studies that do not take these effects into account.

Funding

None.

Research in context

Evidence before this study

We searched PubMed, Google Scholar, medRxiv, and SocArXiv for studies published up to December 08, 2020, using the key words “excess mortality” and “under-registration” or “subregistration,” combined with “coronavirus” or “SARS-CoV-2” or “COVID-19.” We found studies estimating cumulative mortality in high-income countries in Europe and North America solely based on official death counts. We found few studies computing overall COVID-19 mortality in LMICs. Prior research shows a significant percentage of under-registration of deaths in LMICs.

Added value of this study

To our knowledge, we provide the first estimate of excess mortality associated with COVID-19 in a LMIC accounting for both registered and unregistered deaths. We develop an analytical strategy to address common challenges faced by LMICs, such as low completion rates of death certificates, missing data, and inconsistency and variability of data across regions and age groups.

Implications of all the available evidence

Our approach shows the importance of accounting for unregistered deaths based on demographic trends to generate robust estimates of excess mortality associated with COVID-19. It suggests that previous reports of COVID-19 related mortality in Peru were substantial underestimates.

Introduction

Monitoring mortality is an essential part of the public health response to the COVID-19 pandemic. In many countries, accurate COVID-19 mortality monitoring has been hindered by failure to capture all deaths and to attribute causes of deaths to those that are recorded.[1] Disentangling the contribution of COVID-19 to overall mortality is especially challenging, as many people who die from COVID-19 have other conditions, such as cardiovascular disease and diabetes.[2] A further complication is the decision of some countries to apply an arbitrary maximum cut-off time between a positive COVID-19 test and death when deciding whether to attribute mortality to this cause.[3] Also, it is widely documented that the pandemic has led to large numbers of deaths not directly attributable to COVID-19 (either exclusively or in part), due to the wider impacts of responses, including reduced access to treatment for other conditions.[4,5] Conversely, there is evidence that the pandemic has, to a limited extent, reduced expected rates of mortality from causes such as road traffic injuries and homicides during lockdowns.[6]

In the absence of good data on these different mortality effects, robust estimation of all-cause excess mortality offers the most complete and reliable approach for gauging the overall impact of the pandemic on mortality in a defined population over a fixed period of time.[7] Excess mortality refers to the number of additional deaths occurring over a time period when specific conditions apply (in this case, the presence of COVID-19), compared to the number of deaths we might reasonably expect over the same period based on historical data. It captures deaths directly and indirectly attributed to COVID-19 and corresponding responses, to provide an estimate of the overall mortality effect of the pandemic as it unfolds.[8]

Excess mortality estimates have been computed for high-income countries based on registered deaths by surveillance agencies[9,10], academia[11–14] and news agencies.[15–18] However, these types of data are often incomplete or inaccurate, especially in many low and middle-income countries (LMICs). The Global Burden Disease (GBD) project estimates that only 64% of global deaths were registered in 2015.[19] In most LMICs, responsibility for mortality data is often divided between different national and subnational agencies.[20] This can cause extended delays in national reporting and discrepancies between different sources.[12,21] Disaggregation of summary data by different geographical areas or demographic groups is usually very limited.[22] These shortcomings in mortality data explain a lack of published studies of excess mortality in LMICs.[23,24]

We analyse excess mortality associated with the COVID-19 pandemic in Peru during 2020. This country is well-suited to our analytical approach. Like much of Latin America, Peru has experienced high levels of COVID-19 mortality. Official sources report 37,723 deaths directly caused by COVID-19 between 18 March and December 31 2020. However, these only include cases with positive COVID-19 test results and rates of testing in Peru have been low compared to other Latin American countries.[25] Also, many tests have used low sensitivity devices, potentially generating false negatives.[26] On the other hand, Peru does place anonymised individual level data on mortality and COVID-19 in the public domain. Also, the progressive implementation of electronic registration of deaths in recent years enables comparisons of spatial and temporal trends in death registration.[27] Other studies show that unregistered mortality tends to be more prevalent among older people and in poorer regions.[28,29]However, as in many LMICs, Peru does not report sub-national data disaggregated by age.

Potentially, our analytical design could be applied to other countries where mortality registration and cause of death data are incomplete. It may offer a valuable contribution towards assessing the true global impact of the COVID-19 pandemic.

Data and methods

Data

We combine several demographic data sources to forecast mortality rates. These sources are (i) population projections from Peru's National Institute of Statistics and Information (INEI, for its acronym in Spanish) for 2020 disaggregated by region and age group (the most recent census was in 2017); (ii) crude mortality rate estimates disaggregated by region and year from 2015 to 2020 from INEI; (iii) individual-level registered deaths by region and age since 2017 from the Sistema Informático Nacional de Defunciones (SINADEF); and (iv) individual-level registered COVID-19 deaths by region and age in 2020 from the Ministry of Health (MoH).

Excess mortality methods

Our approach to estimate excess mortality decomposes into three terms, namely 1) excess registered deaths, 2) excess unregistered deaths, 3) unregistered COVID-19 deaths. Figure 1 summarises data sources used (squares), analysis performed (diamonds) and different outputs (circles).

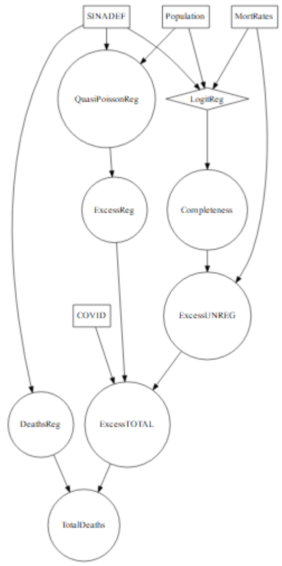

Figure 1: Flowchart: Data, analysis and outputs

To estimate the first term, excess registered deaths, we fit quasi-Poisson regressions to weekly deaths since 2017 by age-groups and region, as follows:

$$(1) log(\text{Deaths}_i) = \beta_0 + \beta_1 \text{COVID-19} + \beta_2 \epsilon_{t-1} + \sum \beta_k \phi_k(\text{Week}) + \log(\text{Pop}) + \epsilon_t$$

where we fit a natural cubic B-spline function $\phi_k(\text{Week})$ on weeks to address long-term trends and seasonality.[30] Additionally, we use lagged residuals ϵ_{t-1} and the log of population in 2020 as an offset. Finally, we compute a dichotomous variable COVID-19 starting in the week corresponding to March 15 2020 as the first registered death of COVID-19 in the country.

Secondly, we compute the population attributable fraction[31] based on the relative risk RR from parameter β_1 in equation (1), as follows:

$$(2) \widehat{\text{Excess}}_{\text{Reg}} = (\text{RR} - 1)/\text{RR} * \text{n}$$

where n is the weekly number of deaths,[32] computed cumulatively over time. To estimate our second term, we predict the logit of death registration completeness for years 2017 and 2019 (years for which data are available).[29] We exploit variability in mortality rates, population aged 60 years and over and rurality to address potential differences in terms of registration completeness. We model random-effects regressions by region using the equation:

$$(3) \begin{aligned} \text{logit}(\text{Reg complete}_{jk}) = \beta_0 + \beta_1 * \text{RegCDR} + \beta_2 * \text{RegCDR}^2 + \\ \beta_3 * \text{complete} < 5 + \beta_4 * \text{P}_{60+} + \beta_5 * \log(5\text{q}0) + \beta_6 * \text{LPG} + \beta_7 * \text{k} + \epsilon_{jk} + \gamma_j \end{aligned}$$

where RegCDR and RegCDR^2 are the Crude Death Rates based on the Registration System, complete < 5 is the completeness registration rate for infants, $log(5\text{q}0)$ is the logarithm under-five mortality rate and P_{60+} represents the fraction of the population at 60 years and over. LPG is the share of households that use liquefied petroleum gas (LPG) for cooking, which is an acceptable proxy for rurality in Peru, where 81.8% of rural households primarily use solid fuel compared to 9.8% of urban households, who typically cook with LPG.[33] Rurality is an important factor to explain delays and underregistration of deaths as the system requires access to internet and computers. Additionally, ϵ_{jk} in the error term and γ_j is the region-level random effect.

Then, we compute the completeness of deaths registration, $\widehat{\text{Completeness}}$ using the inverse logit of the predicted values from equation (3) and $\widehat{\text{Excess}}_{\text{Reg}}$ from equation (2), as follows:

$$(4)\hat{\mu}_{\text{Deaths}_{\text{Not reg}}} = (1 - \widehat{\text{Completeness}}) * \sum \widehat{\text{Excess}}_{\text{Reg}}$$

The third term, unregistered COVID-19 deaths, is computed to correct for situations where the proportion of cumulative cases of COVID-19 exceeds registered deaths for that period. It follows a deterministic approach conditional on excess registered deaths being lower than officially registered COVID-19 deaths for each region and specific age-group as follows:

$$(5)\hat{\mu}_{\text{Deaths}_{\text{COVID not reg}}} = \begin{cases} \hat{\mu}_{\text{Deaths}_{\text{COVID Reg}}} - \hat{\mu}_{\text{Excess}_{\text{Reg}}} & \text{if } \hat{\mu}_{\text{Deaths}_{\text{COVID Reg}}} > \hat{\mu}_{\text{Excess}_{\text{Reg}}}, \\ 0 & \text{if } \hat{\mu}_{\text{Deaths}_{\text{COVID Reg}}} < \hat{\mu}_{\text{Excess}_{\text{Reg}}}. \end{cases}$$

Finally, we estimate total excess deaths for different scenarios.

A first scenario is when there is no solid evidence suggesting under-registration of deaths for some regions or age groups and, therefore, no scope to expand registration over time. This usually occurs in areas and age groups with very small populations. In those cases $\hat{\mu}_{\text{Deaths}_{\text{Not reg}}}$ is set to 0 as, if not, they would add negative values to the sum. A second scenario is related to younger age groups in some regions that have not be significantly affected by COVID-19 mortality. This case corresponds to when β_1 in equation (1) is not statistically significant and therefore we set $\widehat{\text{Excess}}_{\text{Reg}} = 0$. A third scenario is when some groups have fewer deaths than expected, due to effects such as reduced road traffic injuries caused by lockdowns. In these groups $\widehat{\text{Excess}}_{\text{Reg}} \leq 0$ and $\hat{\mu}_{\text{Deaths}_{\text{Not reg}}} = 0$ are taken account of in our final estimation. A fourth scenario is when models underestimate the official number of deaths such as COVID Reg $> \widehat{\text{Excess}}_{\text{Reg}}$. In this case, we use the first as registered deaths. Equation (6) summarises the estimation of $\widehat{\text{Excess}}_{\text{T}_{\text{min/mean/max}}}$ as follows:

$$(6)\widehat{\text{Excess}}_{\text{T}_{\text{min/mean/max}}} = \widehat{\text{Excess}}_{\text{Reg}_{\text{min/mean/max}}} + \hat{\mu}_{\text{Deaths}_{\text{Not reg}}} + \text{Deaths}_{\text{COVID Not Reg}}$$

Finally, we estimate total mortality during 2020 by adding $\widehat{\text{Excess}}_{\text{T}_{\text{min/mean/max}}}$ from equation (6) and the counterfactual difference of SINADEF deaths during 2020 and $\widehat{\text{Excess}}_{\text{Reg}_{\text{min/mean/max}}}$, adjusted by $\widehat{\text{Completeness}}$ as follows:

$$(7)\text{Total}_{\widehat{Mortality}\ 2020} = \widehat{\text{Excess}}_{\text{T}_{\text{min/mean/max}}} + ((\sum_{week=1}^{52} \text{SINADEF}_{2020} - \widehat{\text{Excess}}_{\text{Reg}_{\text{min/mean/max}}}) * (1 + ($$

To address the relative magnitude of mortality in 2020, we compute all cause age-standardised death rates per 1,000 people derived from the estimated total excess deaths. We use the direct standardization methods[34] based on population INEI population estimates by region and age-group for 2020 as the standard population.[35]

As a robustness check for excess mortality estimates, we estimated a mortality baseline for each age group fitting a Generalised Linear Model with Poisson or Negative binomial distributions, depending on the data's overdispersion. The model includes natural splines and sinusoidal components to account for secular changes and seasonality in mortality, as well as interpolated weekly exposures to control for changes in age structure over time. 95% prediction intervals were estimated using 2,000 bootstrapping iterations. Excess mortality is computed as the difference between observed mortality and the baseline, only including weeks in which observed mortality was above the upper prediction interval.

Results

Estimates of completeness of registration derived from our logistic regression model fit the data according to marginal and conditional R^2 and Root Mean Square of Errors parameters. Model fit and goodness-of-fit are presented in Appendix 1. Figure 2 shows important variations in regional completeness rates: Amazonas and Loreto (in Amazonia), Lambayeque (on the coast), and Cajamarca and Pasco (in the Andes) show estimated completion at below 40%, while Ica (coast) and Madre De Dios (Peru's least populated regions in Amazonia) appear to have complete registration (see Appendix 1).

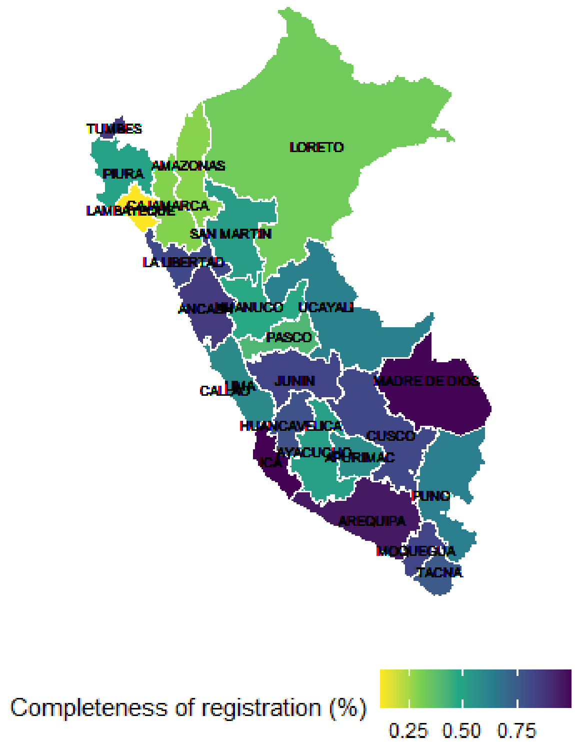

Figure 2: Completeness of registration

Table 1 summarises our estimates of excess mortality. The quasi-Poisson models show a good fit for our first term (weekly excess registered deaths) across models. Excess registered mortality is estimated to be 99,814 (95% CI 85,605 - 110,738), of which 37,724 are reported as COVID-19 deaths. This represents an increase of 165 % (95% CI 127 % - 194 %) compared to MoH data. See Appendix 2 for results and comparison with robustness analysis.

Table 1: Summary of estimations, Peru, 2020.

Terms	Estimates (95% CI)
Excess registered deaths	99,814 (85,605 – 110,738)
Completeness of CRVS deaths registration	30·1 % (28·9 % - 32·7 %)
Excess TOTAL mortality	142,875 (127,163 – 155,739)
Counterfactual estimated deaths in 2020	111,835 (100,911 – 126,044)
Total estimated deaths in 2020	292,230 (262,000 – 324,023)

Table 2 shows estimates by region. Lima, which includes the capital, accounts for 76,158 (95% CI 72,740 – 79,212) total excess deaths, and Apurimac and Pasco show the lowest numbers. Table 3 shows excess mortality estimates by age group. Deaths among people aged 60 years and over accounts for 74·9% of total excess mortality. There was negative excess registered mortality for the youngest three age groups: under 10, 10 to 19 and 20 to 29.

Table 2: Estimated total excess deaths by region

Region	Total excess (TE)	TE - Lower 95% CI	TE - Upper 95% CI	Excess registered (ER)	ER - Lower 95% CI	ER - Upper 95% CI	Excess Covid-19
AMAZONAS	417	256	588.3	163.4	12.14	260.6	136
ANCASH	4,136	3,376	4,764	3,553	2,887	4,096	54
APURIMAC	159	159	159	-70.63	-166.2	-13.74	230
AREQUIPA	4,547	3,390	5,500	4,070	2,688	5,149	254
AYACUCHO	378	378	378	-126.7	-282.4	-34.52	505
CAJAMARCA	2,105	825.9	3,012	1,069	221.3	1,694	191
CALLAO	7,911	7,317	8,392	6,442	5,952	6,830	19
CUSCO	533	533	533	-133.3	-306.4	-20.73	666
HUANCAVELICA	627.2	367.9	814.8	471.4	256.8	622.5	51
HUANUCO	1,128	612.7	1,527	624	279.4	881.9	170
ICA	4,032	3427	4,518	3,929	3,279	4,434	97
JUNIN	2,415	1,328	3,359	1,867	698.1	2,787	193
LA LIBERTAD	6,229	5,010	7,239	5,121	4,097	5,961	105
LAMBAYEQUE	8,532	8,214	8,749	4,533	4,352	4,645	5
LIMA	76,158	72,740	79,212	53,480	51,069	55,626	220
LORETO	4,795	4,309	5,151	2,576	2,061	2,936	294
MADRE DE DIOS	347.9	191.2	453.6	314.3	154.9	414.1	31
MOQUEGUA	833.1	454.5	1085	700.2	368.8	909.2	8
PASCO	342.1	213.8	430.8	125.6	-22.94	221.5	116
PIURA	10,618	9,639	11,412	6,883	6,061	7,521	183
PUNO	711.2	403	997.6	123.6	-285.4	439.4	477
SAN MARTIN	1,847	1,011	2,578	1,068	253.5	1,654	198
TACNA	693	271	1,030	524	102.9	788.8	35
TUMBES	1,074	827.3	1259	931.2	706.5	1,086	3
UCAYALI	2,308	1909	2597	1575	1,169	1,849	102
Total	142,875	127,163	155,739	99,814	85,605	110,738	4,343

Table 3: Estimated total excess deaths by age-group

Age range	Total excess (TE)	TE - Lower 95% CI	TE - Upper 95% CI	Excess registered (ER)	ER - Lower 95% CI	ER - Upper 95% CI	Excess Covid-19
< 9	132	136	136	-1344	-2882	-335.1	1,476
10-19	120.7	121.7	124.5	-21.47	-64.67	4.304	141
20-29	433.2	388	468.6	-177.3	-500.2	33.75	578
30-39	3,197	2,616	3,644	1,942	1,530	2,249	375
40-49	10,012	8,770	10,977	6,981	5,897	7,766	332
50-59	22,030	19,903	23,655	15,740	14,078	16,962	280
60-69	35,736	32,696	38,107	25,587	23,275	27,343	377
70-79	35,740	31,820	38,964	25,700	22,654	28,123	341
> 80	35,473	30,712	39,663	25,408	21,618	28,592	443
Total	142,875	127,163	155,739	99,814	85,605	110,738	4,343

Our second term, excess unregistered deaths, is estimated to be 38,718 deaths (95% CI 40,657 - 37,214). This represents 30.1 % (95% CI 22·0% - 40·1%) of our estimate of the total registered and unregistered deaths. Coastal regions show the highest values where Lima accounts for 22,678 additional deaths, followed by Piura (3,999) and Lambayeque (3,735). Our third term adds 4,343 deaths corresponding to cases when reported COVID-19 deaths exceed our estimate of adjusted excess registered mortality. This mainly occurs for some smaller groups at younger ages. The regions with the highest under reported COVID-19 values are the Andean regions of Ayacucho (505), Cusco (666) and Puno (477).

Combining all these terms, our estimate of total excess deaths during 2020 is 142,875 (95% CI 127,163 - 155,739) and our estimate of total deaths for 2020 is 292,230 (95% CI 262,000 - 324,023). This is 27.8 % (95% CI 13·4% - 41·6%) more than the number of deaths projected by INEI for 2020.

Figure 3 shows all cause age-standardised death rates. We find that Moquegua, Callao, and Lima (CI 95% ranging from 9.11 to 11.5) present the highest rates, ranging from 9·55 to 11·4, while regions of Amazonas, Ayacucho, and Cusco show the lowest rates ranging from 4·82 to 7·26 (CI 95% ranging from 4·62 to 7·41) (left). Figure 3 (right) shows differences deaths per 1000 in comparison to INEI's projections for 2020. We find excess mortality rates in all cases but Amazonas, which shows -1·36 suggesting that INEI overestimates mortality rates projections for 2020 and there is lower use of the CRVS system than expected.

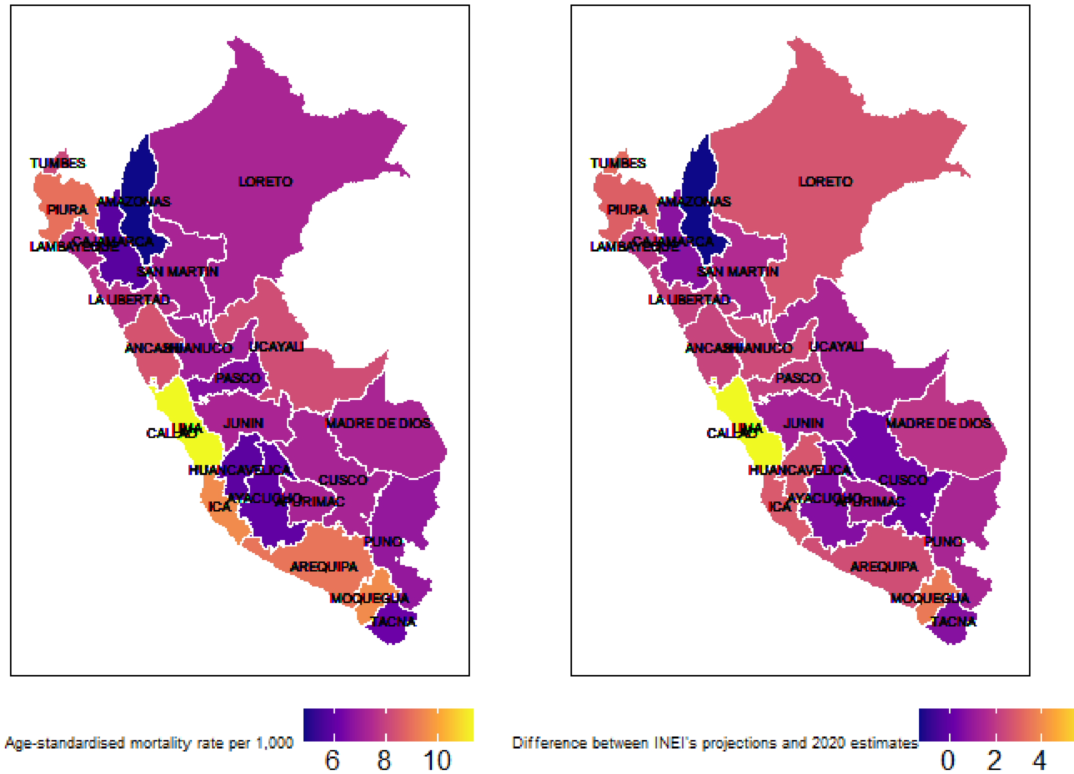

Figure 3: Age-standardised mortality rates

Discussion

The COVID-19 pandemic has underscored the need for methodological advances in population health measurement, research, critical data quality assessment and improvement of health information systems to obtain reliable information on the impact of the pandemic from multiple data sources linked to COVID-19. In this regards, our study provides a framework, tools and analytical strategy to estimate the excess mortality caused by the COVID-19 pandemic in Peru and, potentially, other countries where the quality of mortality data is medium to low.[36] The scope for applying a similar approach will vary between countries. In countries such as India, where mortality and cause of death data are of considerably lower quality than in Peru, achieving robust estimates by any method will be hugely challenging.[37] In other countries, such as Colombia, data quality is similar to Peru's and a recent reform of its CRVS system is likely to have boosted registration rates in the past recent years.[38]

Other published studies of excess COVID-19 mortality fall into two categories. Some studies provide estimates for countries where mortality data are relatively complete and reliable.[39–42] As such, they do not apply specific methods to address data gaps. Studies of excess COVID-19 mortality for countries with less complete data do not take account of unregistered deaths.[43–46]

We estimate that overall excess mortality in Peru was 279 % (95% CI 237 % - 313 %) higher than the level officially attributed to COVID-19. Registered excess mortality was 165 % (95% CI 127 % - 194 %) higher. This is a larger differential than reported by studies for high-income countries. For example, separate studies of the USA show differentials of between 28 and 33%.[11,12] Our estimates are higher than those previously published for Peru, which are only based on registered deaths, and which apply simpler methods.[47,48] Our estimates of regional variations in excess mortality are in line with,[47] who speculate that they may be in part attributable to the effect of altitude of COVID-19 case fatality.

Despite making up a relatively low share of Peru's population (12.5% in 2020), people aged 60 or more accounted for 74.9% of excess mortality. No other published study in Peru provides data disaggregated by age groups. A study of registered excess mortality in six Brazilian cities reports that people aged 60 and over accounted for 71.1% of the total.[44] An analysis of European countries reports that 91% of excess COVID-19 deaths occurred among people aged 65 or more.[41] This reflects a higher proportion of population aged 60 or more in Europe (25.5% in 2020) than in Peru.

Limitations

Our analysis assumes that comparison between years is not invalidated by specific time-bound mortality events such as additional disease outbreaks or other major external shocks. Our estimates of registration completeness assume no variation across age groups, which may not be the case. We do not take into account changes in registration over time as our estimates are based on provisional data, which are incomplete and continue to be fatalities due to COVID-19. Finally, we present a conservative scenario, allowing for the existence of negative as well as positive excess deaths.

Conclusion

There is an evident need for robust estimates of the direct and indirect mortality effects of the COVID-19 pandemic. To date, much of the data for LMICs in the public domain rely on officially-registered deaths. Inaccurate attribution of cause of death can, to some degree, be resolved by generating excess mortality estimates based on temporal comparisons of all-cause mortality. Also, these approaches do not include deaths that are not officially registered. This paper develops and applies a method to obtain robust estimates of excess mortality for both registered and unregistered deaths.

Our study indicates that official data under-represent the overall mortality impact of the COVID-19 pandemic in Peru. This gap is considerably greater than those reported for high-income countries. It is plausible that under-estimation of excess mortality in other countries with low quality mortality data will be comparable to Peru. In that case, LMICs would account for a much larger share of the global distribution of excess mortality associated with the COVID-19 pandemic than indicated by official data sources.

Contributors

LS conceived and initiated the study, did the statistical analysis and visualisations and drafted the manuscript.

PLS conceived and supervised the study, drafted the manuscript and led the editing process of the manuscript.

MM and SE supervised the study and engaged in the draft review & editing

RM contributed in the data curation and methodology process and reviewed & edited the draft.

EA contributed in data curation, methodology and statistical analysis.

LS and EA had access to all the data. All authors approved the manuscript and are responsible for the decision to submit for publication.

Declaration of interests

RM is a staff member of the Pan American Health Organization. The author alone is responsible for the views expressed in this publication, and they do not necessarily represent the decisions or policies of the Pan American Health Organization.

All other authors declare no competing interests.

Data sharing

Data presented in this manuscript are made publicly available at https://github.com/lsempe77/excess

Acknowledgments

Any?

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Appendices

Appendix 1: Model fit registration completeness

Table 4: Model fit Mixed-effect logistic regression

R2m	R2c	RMSE.normalised	RMSE
0.7438	0.8694	0.05282	0.2403

Quasi-Poisson models

Table 5: Model fit Quasi-Poisson

Departamento	range	null.deviance	df.null	logLik	AIC	BIC	deviance	df.residual	nobs	fit	dif.dev	df	p
AMAZONAS	a0.9	62.27	135	NA	NA	NA	54.29	118	136	0.1282	7.98	17	0.967

AMAZONAS	a10.19	23.19	76	NA	NA	NA	20.06	59	77	0.135	3.132	17	0.9999
AMAZONAS	a20.29	26.94	109	NA	NA	NA	22.17	92	110	0.1769	4.765	17	0.9984
AMAZONAS	a30.39	42.37	122	NA	NA	NA	30.56	105	123	0.2786	11.81	17	0.8118
AMAZONAS	a40.49	73.94	154	NA	NA	NA	67.04	137	155	0.09331	6.9	17	0.9848
AMAZONAS	a50.59	135.5	173	NA	NA	NA	106.3	156	174	0.216	29.27	17	0.03209
AMAZONAS	a60.69	266.4	181	NA	NA	NA	160.6	164	182	0.3972	105.8	17	7.357e-15
AMAZONAS	a70.79	229.6	198	NA	NA	NA	210.3	181	199	0.08393	19.27	17	0.3131
AMAZONAS	a80	256.4	203	NA	NA	NA	230.3	186	204	0.1019	26.13	17	0.07212
ANCASH	a0.9	220.7	204	NA	NA	NA	198.6	187	205	0.1002	22.1	17	0.1808
ANCASH	a10.19	101.8	176	NA	NA	NA	96.1	159	177	0.056	5.701	17	0.995
ANCASH	a20.29	159.5	196	NA	NA	NA	140.5	179	197	0.1191	19	17	0.3287
ANCASH	a30.39	191.9	200	NA	NA	NA	168.6	183	201	0.1213	23.27	17	0.1406
ANCASH	a40.49	357.4	205	NA	NA	NA	245.3	188	206	0.3135	112	17	5.009e-16
ANCASH	a50.59	767.2	206	NA	NA	NA	318.1	189	207	0.5853	449.1	17	9.752e-85

ANCASH	a60.69	1100	206	NA	NA	NA	268.2	189	207	0.7561	831.5	17	8.869e-166
ANCASH	a70.79	1088	206	NA	NA	NA	302.2	189	207	0.7222	785.5	17	5.527e-156
ANCASH	a80	748.4	206	NA	NA	NA	268	189	207	0.6419	480.4	17	2.505e-91
APURIMAC	a0.9	102.6	170	NA	NA	NA	88.49	153	171	0.1374	14.1	17	0.6602
APURIMAC	a10.19	20.66	99	NA	NA	NA	15.81	82	100	0.2347	4.85	17	0.9982
APURIMAC	a20.29	50.37	128	NA	NA	NA	42.93	111	129	0.1477	7.439	17	0.9771
APURIMAC	a30.39	76.68	148	NA	NA	NA	66.95	131	149	0.1269	9.73	17	0.9146
APURIMAC	a40.49	114.6	164	NA	NA	NA	94.16	147	165	0.1784	20.45	17	0.2519
APURIMAC	a50.59	185.8	190	NA	NA	NA	146	173	191	0.2141	39.78	17	0.001392
APURIMAC	a60.69	292	199	NA	NA	NA	221.9	182	200	0.2402	70.16	17	2.027e-08
APURIMAC	a70.79	263.7	206	NA	NA	NA	208.6	189	207	0.2091	55.14	17	6.504e-06
APURIMAC	a80	372.9	206	NA	NA	NA	230.9	189	207	0.3807	142	17	9.024e-22
AREQUIPA	a0.9	242.8	202	NA	NA	NA	211	185	203	0.1311	31.83	17	0.0158
AREQUIPA	a10.19	106.2	167	NA	NA	NA	94.33	150	168	0.1119	11.89	17	0.8068

AREQUIPA	a20.29	171.4	199	NA	NA	NA	149	182	200	0.1305	22.37	17	0.1711
AREQUIPA	a30.39	236.7	202	NA	NA	NA	204.6	185	203	0.1354	32.05	17	0.01484
AREQUIPA	a40.49	599.7	204	NA	NA	NA	278.4	187	205	0.5357	321.3	17	4.543e-58
AREQUIPA	a50.59	1486	206	NA	NA	NA	313.8	189	207	0.7888	1172	17	1.261e-238
AREQUIPA	a60.69	2417	206	NA	NA	NA	337.9	189	207	0.8602	2079	17	0
AREQUIPA	a70.79	2435	206	NA	NA	NA	329	189	207	0.8649	2106	17	0
AREQUIPA	a80	2587	206	NA	NA	NA	326.9	189	207	0.8736	2260	17	0
AYACUCHO	a0.9	165.6	170	NA	NA	NA	117.5	153	171	0.2908	48.15	17	0.00008135
AYACUCHO	a10.19	55.2	124	NA	NA	NA	48.86	107	125	0.1148	6.339	17	0.9906
AYACUCHO	a20.29	103.6	170	NA	NA	NA	89.06	153	171	0.1403	14.53	17	0.629
AYACUCHO	a30.39	92.51	159	NA	NA	NA	78.74	142	160	0.1488	13.77	17	0.6836
AYACUCHO	a40.49	153.3	171	NA	NA	NA	127.7	154	172	0.1671	25.62	17	0.08166
AYACUCHO	a50.59	212.8	190	NA	NA	NA	168.9	173	191	0.2064	43.93	17	0.0003502
AYACUCHO	a60.69	316.1	200	NA	NA	NA	181.8	183	201	0.4248	134.3	17	2.795e-20

AYACUCHO	a70.79	443.8	203	NA	NA	NA	229.2	186	204	0.4835	214.6	17	3.297e-36
AYACUCHO	a80	431.4	205	NA	NA	NA	199.2	188	206	0.5384	232.2	17	8.658e-40
CAJAMARCA	a0.9	264.3	204	NA	NA	NA	224.2	187	205	0.1515	40.04	17	0.001276
CAJAMARCA	a10.19	58.14	141	NA	NA	NA	52.77	124	142	0.09232	5.367	17	0.9965
CAJAMARCA	a20.29	118.3	178	NA	NA	NA	102.7	161	179	0.1317	15.58	17	0.5538
CAJAMARCA	a30.39	199.4	192	NA	NA	NA	162.3	175	193	0.186	37.09	17	0.003276
CAJAMARCA	a40.49	221	200	NA	NA	NA	162.4	183	201	0.2653	58.63	17	1.768e-06
CAJAMARCA	a50.59	532.6	205	NA	NA	NA	259.4	188	206	0.5131	273.3	17	3.594e-48
CAJAMARCA	a60.69	865.8	206	NA	NA	NA	340.5	189	207	0.6068	525.4	17	8.453e-101
CAJAMARCA	a70.79	691.9	206	NA	NA	NA	287.6	189	207	0.5843	404.3	17	2.356e-75
CAJAMARCA	a80	531.5	206	NA	NA	NA	238.7	189	207	0.5508	292.8	17	3.505e-52
CALLAO	a0.9	225.1	194	NA	NA	NA	201.8	177	195	0.1035	23.28	17	0.1403
CALLAO	a10.19	56.25	133	NA	NA	NA	49.22	116	134	0.125	7.028	17	0.9832
CALLAO	a20.29	191.4	194	NA	NA	NA	171.9	177	195	0.102	19.53	17	0.2989

CALLAO	a30.39	252.6	201	NA	NA	NA	186.6	184	202	0.2612	65.98	17	1.051e-07
CALLAO	a40.49	713.4	205	NA	NA	NA	245.7	188	206	0.6556	467.7	17	1.168e-88
CALLAO	a50.59	1458	206	NA	NA	NA	289.3	189	207	0.8015	1168	17	8.475e-238
CALLAO	a60.69	2350	206	NA	NA	NA	330.7	189	207	0.8593	2020	17	0
CALLAO	a70.79	1970	206	NA	NA	NA	374	189	207	0.8102	1596	17	0
CALLAO	a80	1412	206	NA	NA	NA	358	189	207	0.7466	1054	17	1.991e-213
CUSCO	a0.9	284.1	206	NA	NA	NA	216.1	189	207	0.2393	68	17	4.747e-08
CUSCO	a10.19	162.2	198	NA	NA	NA	152.1	181	199	0.06261	10.16	17	0.8969
CUSCO	a20.29	247.8	203	NA	NA	NA	211.9	186	204	0.1449	35.9	17	0.004733
CUSCO	a30.39	194.3	203	NA	NA	NA	164.2	186	204	0.155	30.13	17	0.02544
CUSCO	a40.49	369	206	NA	NA	NA	279.7	189	207	0.2419	89.27	17	8.292e-12
CUSCO	a50.59	456.4	206	NA	NA	NA	282.3	189	207	0.3814	174.1	17	4.399e-28
CUSCO	a60.69	813.6	206	NA	NA	NA	345.8	189	207	0.575	467.8	17	1.133e-88
CUSCO	a70.79	663	206	NA	NA	NA	295.9	189	207	0.5538	367.2	17	1.305e-67

CUSCO	a80	829.8	206	NA	NA	NA	309	189	207	0.6276	520.8	17	7.665e-100
HUANCAVELICA	a0.9	174.5	197	NA	NA	NA	157.9	180	198	0.095	16.57	17	0.4837
HUANCAVELICA	a10.19	69.99	128	NA	NA	NA	54.41	111	129	0.2225	15.57	17	0.5545
HUANCAVELICA	a20.29	73.45	146	NA	NA	NA	63.6	129	147	0.1342	9.857	17	0.9095
HUANCAVELICA	a30.39	85.91	164	NA	NA	NA	76.35	147	165	0.1112	9.555	17	0.9212
HUANCAVELICA	a40.49	162.6	177	NA	NA	NA	139.6	160	178	0.1415	23	17	0.1492
HUANCAVELICA	a50.59	199.9	195	NA	NA	NA	154.3	178	196	0.2281	45.59	17	0.0001987
HUANCAVELICA	a60.69	294.9	204	NA	NA	NA	231.5	187	205	0.2149	63.38	17	2.88e-07
HUANCAVELICA	a70.79	352.3	205	NA	NA	NA	253.4	188	206	0.2808	98.95	17	1.392e-13
HUANCAVELICA	a80	260.7	206	NA	NA	NA	203.7	189	207	0.2186	56.99	17	3.266e-06
HUANUCO	a0.9	195.8	204	NA	NA	NA	175.8	187	205	0.1019	19.95	17	0.2768
HUANUCO	a10.19	93.14	155	NA	NA	NA	78.01	138	156	0.1624	15.12	17	0.5867
HUANUCO	a20.29	132	193	NA	NA	NA	123.1	176	194	0.06755	8.918	17	0.9428
HUANUCO	a30.39	156.4	191	NA	NA	NA	140.5	174	192	0.1016	15.89	17	0.5319

HUANUCO	a40.49	227.2	200	NA	NA	NA	180.8	183	201	0.2043	46.43	17	0.0001485
HUANUCO	a50.59	329.1	206	NA	NA	NA	265	189	207	0.1945	64.02	17	2.25e-07
HUANUCO	a60.69	421.4	206	NA	NA	NA	210.9	189	207	0.4996	210.6	17	2.141e-35
HUANUCO	a70.79	363.2	206	NA	NA	NA	233.5	189	207	0.3572	129.7	17	2.115e-19
HUANUCO	a80	359.2	206	NA	NA	NA	253.9	189	207	0.2931	105.3	17	9.331e-15
ICA	a0.9	157.3	200	NA	NA	NA	141.7	183	201	0.09878	15.53	17	0.5571
ICA	a10.19	44.47	134	NA	NA	NA	35.35	117	135	0.2051	9.119	17	0.9365
ICA	a20.29	158.7	186	NA	NA	NA	142.4	169	187	0.1025	16.27	17	0.505
ICA	a30.39	236.1	195	NA	NA	NA	200.6	178	196	0.1502	35.47	17	0.005402
ICA	a40.49	556.1	205	NA	NA	NA	253.1	188	206	0.5448	303	17	2.707e-54
ICA	a50.59	1030	206	NA	NA	NA	295.2	189	207	0.7134	734.8	17	3.479e-145
ICA	a60.69	1669	206	NA	NA	NA	316.4	189	207	0.8104	1352	17	2.543e-277
ICA	a70.79	1128	206	NA	NA	NA	319.6	189	207	0.7165	807.9	17	9.517e-161
ICA	a80	932.6	206	NA	NA	NA	373.4	189	207	0.5996	559.2	17	5.978e-108

JUNIN	a0.9	229.1	205	NA	NA	NA	202.2	188	206	0.1175	26.92	17	0.05932
JUNIN	a10.19	145.9	187	NA	NA	NA	134.8	170	188	0.0761	11.1	17	0.8512
JUNIN	a20.29	198.7	205	NA	NA	NA	185.1	188	206	0.06805	13.52	17	0.7008
JUNIN	a30.39	268.4	205	NA	NA	NA	245.1	188	206	0.08653	23.22	17	0.1421
JUNIN	a40.49	426.1	205	NA	NA	NA	270.4	188	206	0.3654	155.7	17	1.883e-24
JUNIN	a50.59	814	206	NA	NA	NA	311.5	189	207	0.6173	502.5	17	5.607e-96
JUNIN	a60.69	1019	206	NA	NA	NA	325.3	189	207	0.6806	693.3	17	2.32e-136
JUNIN	a70.79	827.1	206	NA	NA	NA	277.2	189	207	0.6648	549.9	17	5.625e-106
JUNIN	a80	730.8	206	NA	NA	NA	265.3	189	207	0.637	465.6	17	3.353e-88
LA LIBERTAD	a0.9	249.4	206	NA	NA	NA	213.8	189	207	0.1425	35.54	17	0.00528
LA LIBERTAD	a10.19	182.7	190	NA	NA	NA	173.4	173	191	0.05081	9.281	17	0.931
LA LIBERTAD	a20.29	251.2	204	NA	NA	NA	227.5	187	205	0.0943	23.69	17	0.1282
LA LIBERTAD	a30.39	281.8	206	NA	NA	NA	241	189	207	0.1448	40.81	17	0.0009931
LA LIBERTAD	a40.49	524.4	206	NA	NA	NA	253.8	189	207	0.516	270.6	17	1.276e-47

LA LIBERTAD	a50.59	1406	206	NA	NA	NA	325	189	207	0.7689	1081	17	3.763e-219
LA LIBERTAD	a60.69	2229	206	NA	NA	NA	354.1	189	207	0.8411	1874	17	0
LA LIBERTAD	a70.79	1934	206	NA	NA	NA	403.1	189	207	0.7916	1531	17	9.19e-316
LA LIBERTAD	a80	1272	206	NA	NA	NA	372.8	189	207	0.7068	898.9	17	3.59e-180
LAMBAYEQUE	a0.9	340.7	181	NA	NA	NA	148.6	164	182	0.5639	192.1	17	1.089e-31
LAMBAYEQUE	a10.19	57.98	118	NA	NA	NA	43.18	101	119	0.2553	14.8	17	0.6096
LAMBAYEQUE	a20.29	153.8	159	NA	NA	NA	91.66	142	160	0.4041	62.15	17	4.615e-07
LAMBAYEQUE	a30.39	207	173	NA	NA	NA	147.9	156	174	0.2854	59.08	17	1.49e-06
LAMBAYEQUE	a40.49	581.6	182	NA	NA	NA	277.2	165	183	0.5234	304.4	17	1.371e-54
LAMBAYEQUE	a50.59	1082	184	NA	NA	NA	284	167	185	0.7375	798	17	1.197e-158
LAMBAYEQUE	a60.69	1985	193	NA	NA	NA	427.7	176	194	0.7846	1558	17	2.016e-321
LAMBAYEQUE	a70.79	2114	199	NA	NA	NA	385.4	182	200	0.8177	1729	17	0
LAMBAYEQUE	a80	3676	202	NA	NA	NA	610.7	185	203	0.8339	3065	17	0
LIMA	a0.9	348.6	206	NA	NA	NA	275	189	207	0.2112	73.64	17	5.054e-09

LIMA	a10.19	253.8	206	NA	NA	NA	209.4	189	207	0.1752	44.47	17	0.0002917
LIMA	a20.29	410.1	206	NA	NA	NA	309.5	189	207	0.2452	100.6	17	6.992e-14
LIMA	a30.39	1254	206	NA	NA	NA	263.1	189	207	0.7902	991.2	17	6.901e-200
LIMA	a40.49	4855	206	NA	NA	NA	443.6	189	207	0.9086	4411	17	0
LIMA	a50.59	12239	206	NA	NA	NA	740.1	189	207	0.9395	11499	17	0
LIMA	a60.69	20219	206	NA	NA	NA	1093	189	207	0.9459	19126	17	0
LIMA	a70.79	17310	206	NA	NA	NA	1001	189	207	0.9422	16309	17	0
LIMA	a80	14400	206	NA	NA	NA	720	189	207	0.95	13680	17	0
LORETO	a0.9	225.3	204	NA	NA	NA	200.7	187	205	0.1091	24.59	17	0.1044
LORETO	a10.19	84.68	150	NA	NA	NA	67.96	133	151	0.1974	16.72	17	0.4735
LORETO	a20.29	148	190	NA	NA	NA	135.8	173	191	0.08225	12.17	17	0.7896
LORETO	a30.39	234.6	199	NA	NA	NA	171.9	182	200	0.2669	62.62	17	3.866e-07
LORETO	a40.49	412.2	202	NA	NA	NA	194.7	185	203	0.5277	217.5	17	8.322e-37
LORETO	a50.59	806.8	204	NA	NA	NA	268.4	187	205	0.6673	538.4	17	1.527e-103

LORETO	a60.69	1591	204	NA	NA	NA	394	187	205	0.7524	1197	17	5.069e-244
LORETO	a70.79	1357	205	NA	NA	NA	397.5	188	206	0.7071	959.6	17	3.915e-193
LORETO	a80	806.5	206	NA	NA	NA	326.9	189	207	0.5947	479.6	17	3.8e-91
MADRE DE DIOS	a0.9	78.23	130	NA	NA	NA	64.36	113	131	0.1773	13.87	17	0.6765
MADRE DE DIOS	a10.19	16.24	78	NA	NA	NA	12.75	61	79	0.2148	3.487	17	0.9998
MADRE DE DIOS	a20.29	75.72	151	NA	NA	NA	69.89	134	152	0.07695	5.826	17	0.9943
MADRE DE DIOS	a30.39	72.37	139	NA	NA	NA	63.19	122	140	0.1269	9.181	17	0.9344
MADRE DE DIOS	a40.49	99.54	149	NA	NA	NA	80.36	132	150	0.1927	19.18	17	0.3183
MADRE DE DIOS	a50.59	205.3	162	NA	NA	NA	108.6	145	163	0.471	96.68	17	3.656e-13
MADRE DE DIOS	a60.69	251.4	170	NA	NA	NA	119.3	153	171	0.5254	132.1	17	7.428e-20
MADRE DE DIOS	a70.79	197	168	NA	NA	NA	119.4	151	169	0.3937	77.56	17	1.038e-09
MADRE DE DIOS	a80	159.4	166	NA	NA	NA	96.93	149	167	0.3919	62.48	17	4.071e-07
MOQUEGUA	a0.9	20.19	78	NA	NA	NA	14.53	61	79	0.2804	5.661	17	0.9952
MOQUEGUA	a10.19	6.284	37	NA	NA	NA	1.483	20	38	0.764	4.801	17	0.9983

MOQUEGUA	a20.29	16.63	82	NA	NA	NA	12.43	65	83	0.2526	4.201	17	0.9993
MOQUEGUA	a30.39	16.13	81	NA	NA	NA	11.12	64	82	0.3108	5.013	17	0.9977
MOQUEGUA	a40.49	93.28	123	NA	NA	NA	52.96	106	124	0.4322	40.31	17	0.00117
MOQUEGUA	a50.59	242.7	151	NA	NA	NA	79.88	134	152	0.6709	162.9	17	7.281e-26
MOQUEGUA	a60.69	550.9	184	NA	NA	NA	174.3	167	185	0.6835	376.5	17	1.488e-69
MOQUEGUA	a70.79	699.7	198	NA	NA	NA	253.6	181	199	0.6376	446.1	17	4.058e-84
MOQUEGUA	a80	509.4	205	NA	NA	NA	233.6	188	206	0.5414	275.8	17	1.1e-48
PASCO	a0.9	67.77	141	NA	NA	NA	57.4	124	142	0.1531	10.38	17	0.887
PASCO	a10.19	14.81	61	NA	NA	NA	8.657	44	62	0.4156	6.156	17	0.9921
PASCO	a20.29	26.91	104	NA	NA	NA	22.96	87	105	0.1465	3.943	17	0.9995
PASCO	a30.39	51.29	106	NA	NA	NA	39.45	89	107	0.2308	11.84	17	0.8098
PASCO	a40.49	61.74	130	NA	NA	NA	42.05	113	131	0.3189	19.69	17	0.2906
PASCO	a50.59	138.8	156	NA	NA	NA	89.34	139	157	0.3563	49.45	17	0.00005147
PASCO	a60.69	192.3	166	NA	NA	NA	99.85	149	167	0.4807	92.43	17	2.196e-12

PASCO	a70.79	225.4	188	NA	NA	NA	150.5	171	189	0.3324	74.93	17	3.01e-09
PASCO	a80	273.9	194	NA	NA	NA	199.2	177	195	0.2728	74.72	17	3.276e-09
PIURA	a0.9	246	206	NA	NA	NA	199.7	189	207	0.1882	46.31	17	0.000155
PIURA	a10.19	120.1	170	NA	NA	NA	104.6	153	171	0.1289	15.48	17	0.5612
PIURA	a20.29	208.1	197	NA	NA	NA	176.1	180	198	0.1539	32.01	17	0.01498
PIURA	a30.39	353	203	NA	NA	NA	202.9	186	204	0.4254	150.2	17	2.269e-23
PIURA	a40.49	899.9	203	NA	NA	NA	314	186	204	0.651	585.9	17	1.383e-113
PIURA	a50.59	1575	206	NA	NA	NA	311	189	207	0.8025	1263	17	3.151e-258
PIURA	a60.69	3123	206	NA	NA	NA	398.1	189	207	0.8725	2725	17	0
PIURA	a70.79	2392	206	NA	NA	NA	420.1	189	207	0.8244	1972	17	0
PIURA	a80	1749	206	NA	NA	NA	423.6	189	207	0.7578	1325	17	1.728e-271
PUNO	a0.9	225.3	205	NA	NA	NA	164.4	188	206	0.2704	60.93	17	7.387e-07
PUNO	a10.19	126.6	180	NA	NA	NA	115.1	163	181	0.09076	11.49	17	0.8302
PUNO	a20.29	191.2	202	NA	NA	NA	172.9	185	203	0.09582	18.32	17	0.3689

PUNO	a30.39	295	206	NA	NA	NA	272	189	207	0.07794	22.99	17	0.1496
PUNO	a40.49	370.5	206	NA	NA	NA	246.3	189	207	0.3351	124.1	17	2.49e-18
PUNO	a50.59	730.5	206	NA	NA	NA	323.8	189	207	0.5568	406.7	17	7.225e-76
PUNO	a60.69	959.1	206	NA	NA	NA	288.5	189	207	0.6992	670.7	17	1.484e-131
PUNO	a70.79	863.2	206	NA	NA	NA	289.2	189	207	0.665	574	17	4.525e-111
PUNO	a80	703.8	206	NA	NA	NA	312.5	189	207	0.556	391.3	17	1.203e-72
SAN MARTIN	a0.9	239.4	203	NA	NA	NA	191.9	186	204	0.1986	47.55	17	0.0001007
SAN MARTIN	a10.19	95.83	149	NA	NA	NA	70.97	132	150	0.2594	24.86	17	0.09781
SAN MARTIN	a20.29	125.7	191	NA	NA	NA	106.8	174	192	0.1509	18.98	17	0.3299
SAN MARTIN	a30.39	204.8	198	NA	NA	NA	166.7	181	199	0.1858	38.05	17	0.002418
SAN MARTIN	a40.49	313.7	205	NA	NA	NA	207.5	188	206	0.3384	106.2	17	6.318e-15
SAN MARTIN	a50.59	487.4	204	NA	NA	NA	253.8	187	205	0.4794	233.6	17	4.51e-40
SAN MARTIN	a60.69	763.5	206	NA	NA	NA	284.1	189	207	0.6279	479.3	17	4.211e-91
SAN MARTIN	a70.79	566.7	205	NA	NA	NA	255.3	188	206	0.5496	311.5	17	4.821e-56

SAN MARTIN	a80	743.5	206	NA	NA	NA	316.8	189	207	0.5739	426.7	17	4.739e-80
TACNA	a0.9	54.54	124	NA	NA	NA	43.29	107	125	0.2063	11.25	17	0.8433
TACNA	a10.19	6.653	61	NA	NA	NA	4.698	44	62	0.2939	1.955	17	1
TACNA	a20.29	47.05	115	NA	NA	NA	40.73	98	116	0.1344	6.322	17	0.9907
TACNA	a30.39	83.11	154	NA	NA	NA	74.56	137	155	0.1029	8.555	17	0.9532
TACNA	a40.49	156.1	172	NA	NA	NA	109.6	155	173	0.298	46.52	17	0.0001442
TACNA	a50.59	329.6	186	NA	NA	NA	210	169	187	0.3628	119.6	17	1.863e-17
TACNA	a60.69	610.7	201	NA	NA	NA	263.6	184	202	0.5684	347.1	17	2e-63
TACNA	a70.79	464.9	204	NA	NA	NA	287.4	187	205	0.3818	177.5	17	9.067e-29
TACNA	a80	358.3	206	NA	NA	NA	306.6	189	207	0.1443	51.7	17	0.00002288
TUMBES	a0.9	53.94	133	NA	NA	NA	46.3	116	134	0.1416	7.64	17	0.9737
TUMBES	a10.19	5.624	57	NA	NA	NA	4.239	40	58	0.2462	1.385	17	1
TUMBES	a20.29	26.32	107	NA	NA	NA	22.29	90	108	0.1531	4.029	17	0.9995
TUMBES	a30.39	52.44	136	NA	NA	NA	42.63	119	137	0.1871	9.812	17	0.9113

TUMBES	a40.49	93.67	152	NA	NA	NA	68.08	135	153	0.2732	25.59	17	0.08216
TUMBES	a50.59	267.8	174	NA	NA	NA	130.7	157	175	0.5118	137	17	8.15e-21
TUMBES	a60.69	491.9	195	NA	NA	NA	198.8	178	196	0.5957	293	17	3.091e-52
TUMBES	a70.79	368.9	195	NA	NA	NA	196.5	178	196	0.4673	172.4	17	9.323e-28
TUMBES	a80	384.6	205	NA	NA	NA	235.3	188	206	0.388	149.2	17	3.464e-23
UCAYALI	a0.9	199.1	192	NA	NA	NA	155.9	175	193	0.2173	43.27	17	0.0004387
UCAYALI	a10.19	45.36	123	NA	NA	NA	38.54	106	124	0.1504	6.824	17	0.9857
UCAYALI	a20.29	167.7	176	NA	NA	NA	147.8	159	177	0.1186	19.9	17	0.2796
UCAYALI	a30.39	173.3	176	NA	NA	NA	133.6	159	177	0.2292	39.72	17	0.001416
UCAYALI	a40.49	242	198	NA	NA	NA	187.2	181	199	0.2266	54.85	17	7.247e-06
UCAYALI	a50.59	483.2	200	NA	NA	NA	247.9	183	201	0.487	235.3	17	2.07e-40
UCAYALI	a60.69	701.2	206	NA	NA	NA	254.1	189	207	0.6377	447.2	17	2.435e-84
UCAYALI	a70.79	915.9	203	NA	NA	NA	316.5	186	204	0.6545	599.5	17	1.861e-116
UCAYALI	a80	613.5	205	NA	NA	NA	313.2	188	206	0.4895	300.3	17	9.699e-54

Under-registration rates

Table 6: Under-registration rates

Departamento	sub.mean
ICA	99.85
MADRE DE DIOS	99.17
AREQUIPA	94.81
ANCASH	85.12
TUMBES	85.04
JUNIN	82.32
MOQUEGUA	82.15
CUSCO	80.81
LA LIBERTAD	80.42
HUANCAVELICA	77.77
CALLAO	77.49
TACNA	74.44
PUNO	62.28
UCAYALI	61.8
LIMA	58.01
APURIMAC	57
SAN MARTIN	51.53
AYACUCHO	50.53
PIURA	49.41
HUANUCO	46.54
PASCO	40.6
LORETO	32.09
CAJAMARCA	28.41
AMAZONAS	27.99
LAMBAYEQUE	11.89

Age-standardised deaths rates

Table 7: Age-standardised deaths rates

Departamento	adj.rate	lci	uci	crude.rate	2010	2015	Difference
AMAZONAS	4.824	4.618	5.037	4.828	6.05	6.19	-1.362
ANCASH	8.412	8.247	8.579	8.387	6.09	6.15	2.237
APURIMAC	7.258	7.016	7.506	7.881	6.76	6.61	1.271
AREQUIPA	9.123	8.963	9.285	8.274	5.53	5.8	2.474
AYACUCHO	5.977	5.8	6.157	6.49	6.15	5.91	0.5802

CAJAMARCA	5.831	5.711	5.952	6.194	5.39	5.5	0.6941
CALLAO	11.01	10.81	11.21	10.54	4.91	5.27	5.267
CUSCO	7.262	7.119	7.407	7.238	6.88	6.97	0.2676
HUANCAVELICA	5.889	5.68	6.103	8.25	5.83	5.54	2.71
HUANUCO	7.167	6.992	7.345	8.379	5.94	5.98	2.399
ICA	9.541	9.331	9.754	8.072	4.99	5.29	2.782
JUNIN	7.316	7.175	7.459	7.514	6.17	6.24	1.274
LA LIBERTAD	7.7	7.578	7.823	7.534	5.24	5.39	2.144
LAMBAYEQUE	7.469	7.322	7.619	7.463	5.25	5.55	1.913
LIMA	11.44	11.38	11.51	11.42	5.13	5.4	6.023
LORETO	7.304	7.144	7.467	7.715	4.92	5.07	2.645
MADRE DE DIOS	7.299	6.877	7.74	6.432	4.4	4.54	1.892
MOQUEGUA	9.547	9.112	9.997	9.396	5.49	5.86	3.536
PASCO	6.606	6.325	6.896	7.645	5.54	5.54	2.105
PIURA	9.029	8.895	9.165	8.44	5.36	5.5	2.94
PUNO	6.87	6.737	7.004	8.242	7.01	6.86	1.382
SAN MARTIN	7.28	7.104	7.459	7.239	5.47	5.63	1.609
TACNA	6.175	5.922	6.436	6.031	5.09	5.4	0.631
TUMBES	8.139	7.79	8.499	8.134	4.7	4.94	3.194
UCAYALI	8.261	8.016	8.511	7.335	5.68	5.93	1.405

Counterfacutual and total deaths 2020

Table 8: Counterfacutual and total deaths 2020

Departamento	range	sinadef	excess.T	excess.l	excess.u	excess.reg	excess.reg.l	excess.reg.u	count	count.l	count.u	total	total.l	total.u
AMAZONAS	a0.9	60	0	1	1	0	0	0	60	60	60	103.2	104.2	104.2
AMAZONAS	a10.19	22	0	1	1	0	0	0	22	22	22	37.84	38.84	38.84
AMAZONAS	a20.29	36	5	5	5	0	0	0	36	36	36	66.92	66.92	66.92
AMAZONAS	a30.39	60	11	11	11	0	0	0	60	60	60	114.2	114.2	114.2

AMAZONAS	a40.49	83	15	15	15	0	0	0	83	83	83	157.8	157.8	157.8
AMAZONAS	a50.59	123	41	41	41	0	0	0	123	123	123	252.6	252.6	252.6
AMAZONAS	a60.69	199	123.1	60	196	71.59	0.01299	113.4	127.4	85.62	199	342.3	207.3	538.3
AMAZONAS	a70.79	199	64	64	64	0	0	0	199	199	199	406.3	406.3	406.3
AMAZONAS	a80	337	157.9	58	254.2	91.79	12.13	147.2	245.2	189.8	324.9	579.7	384.5	813.1
ANCASH	a0.9	243	3	3	3	0	0	0	243	243	243	282.2	282.2	282.2
ANCASH	a10.19	101	2	2	2	0	0	0	101	101	101	118	118	118
ANCASH	a20.29	163	12	12	12	0	0	0	163	163	163	199.3	199.3	199.3
ANCASH	a30.39	224	37	37	37	0	0	0	224	224	224	294.3	294.3	294.3
ANCASH	a40.49	471	268	186.7	327.7	233.2	161.6	284.4	237.8	186.6	309.4	541.1	401.1	683.1
ANCASH	a50.59	890	568.8	450	659.4	495.1	390.8	573.1	394.9	316.9	499.2	1022	814.1	1233
ANCASH	a60.69	1390	1014	903.1	1104	882.4	785.2	959.9	507.6	430.1	604.8	1597	1397	1799
ANCASH	a70.79	1960	1245	1084	1379	1084	942.6	1200	876.5	760.4	1017	2252	1957	2548
ANCASH	a80	3130	986.2	697.9	1240	858.5	606.7	1079	2272	2051	2523	3596	3055	4139
APURIMAC	a0.9	100	2	2	2	-70.63	-166.2	-13.74	170.6	113.7	266.2	246	164.6	382.6

APURIMAC	a10.19	51	3	3	3	0	0	0	51	51	51	75.93	75.93	75.93
APURIMAC	a20.29	64	7	7	7	0	0	0	64	64	64	98.52	98.52	98.52
APURIMAC	a30.39	73	5	5	5	0	0	0	73	73	73	109.4	109.4	109.4
APURIMAC	a40.49	119	11	11	11	0	0	0	119	119	119	181.2	181.2	181.2
APURIMAC	a50.59	200	26	26	26	0	0	0	200	200	200	312	312	312
APURIMAC	a60.69	275	23	23	23	0	0	0	275	275	275	416.2	416.2	416.2
APURIMAC	a70.79	447	39	39	39	0	0	0	447	447	447	678.2	678.2	678.2
APURIMAC	a80	863	43	43	43	0	0	0	863	863	863	1277	1277	1277
AREQUIPA	a0.9	216	4	4	4	-120.1	-271.9	-22.54	336.1	238.5	487.9	357.6	254.9	517.3
AREQUIPA	a10.19	98	8	8	8	0	0	0	98	98	98	111.1	111.1	111.1
AREQUIPA	a20.29	232	12	12	12	-81.27	-197.8	-1.14	313.3	233.1	429.8	341.5	257.2	464.2
AREQUIPA	a30.39	329	29	29	29	0	0	0	329	329	329	375.1	375.1	375.1
AREQUIPA	a40.49	662	251.3	124	352.7	238.9	106.6	334.4	423.1	327.6	555.4	696.4	468.6	937
AREQUIPA	a50.59	1213	666.6	508	787.5	633.7	482	747.6	579.3	465.4	731	1276	997.5	1556

AREQUIPA	a60.69	1990	1102	887.9	1273	1048	843.2	1209	942.1	780.5	1147	2093	1709	2480
AREQUIPA	a70.79	2480	1119	852.7	1339	1064	809.7	1272	1416	1208	1670	2609	2123	3096
AREQUIPA	a80	4307	1354	964.7	1694	1287	916.2	1609	3020	2698	3391	4531	3802	5261
AYACUCHO	a0.9	122	1	1	1	-126.7	-282.4	-34.52	248.7	156.5	404.4	372.7	235	605.4
AYACUCHO	a10.19	62	3	3	3	0	0	0	62	62	62	95.67	95.67	95.67
AYACUCHO	a20.29	94	3	3	3	0	0	0	94	94	94	143.5	143.5	143.5
AYACUCHO	a30.39	100	11	11	11	0	0	0	100	100	100	160.5	160.5	160.5
AYACUCHO	a40.49	161	24	24	24	0	0	0	161	161	161	264.6	264.6	264.6
AYACUCHO	a50.59	214	51	51	51	0	0	0	214	214	214	370.9	370.9	370.9
AYACUCHO	a60.69	373	101	101	101	0	0	0	373	373	373	658.5	658.5	658.5
AYACUCHO	a70.79	554	106	106	106	0	0	0	554	554	554	934	934	934
AYACUCHO	a80	842	78	78	78	0	0	0	842	842	842	1337	1337	1337
CAJAMARCA	a0.9	231	2	2	2	-110.3	-266.3	-11.15	341.3	242.1	497.3	587.7	417.5	855.3
CAJAMARCA	a10.19	75	3	3	3	0	0	0	75	75	75	131.7	131.7	131.7

CAJAMARCA	a20.29	128	6	6	6	0	0	0	128	128	128	225.6	225.6	225.6
CAJAMARCA	a30.39	207	24	24	24	0	0	0	207	207	207	379.2	379.2	379.2
CAJAMARCA	a40.49	294	46	46	46	0	0	0	294	294	294	550.5	550.5	550.5
CAJAMARCA	a50.59	538	364.4	174.7	498.3	212.4	101.2	289.8	325.6	248.2	436.8	923.2	600.5	1248
CAJAMARCA	a60.69	792	465.8	152	689.2	271.4	86.67	401.1	520.6	390.9	705.3	1359	822.8	1900
CAJAMARCA	a70.79	1072	559.6	154	797.8	326.1	146.3	464.4	745.9	607.6	925.7	1839	1197	2386
CAJAMARCA	a80	1753	633.9	264.3	945.3	369.4	153.4	550.3	1384	1203	1600	3008	2328	3690
CALLAO	a0.9	156	3	3	3	0	0	0	156	156	156	194.1	194.1	194.1
CALLAO	a10.19	49	1	1	1	0	0	0	49	49	49	61.03	61.03	61.03
CALLAO	a20.29	185	15	15	15	0	0	0	185	185	185	241.7	241.7	241.7
CALLAO	a30.39	319	161.4	85.81	214.7	131.8	69.23	174.4	187.2	144.6	249.8	390.8	262.9	520.7
CALLAO	a40.49	639	587.7	536	626.7	479.7	436.7	510.7	159.3	128.3	202.3	782.9	693.2	874.6
CALLAO	a50.59	1192	1193	1141	1234	973.6	930.2	1007	218.4	185.2	261.8	1460	1368	1555
CALLAO	a60.69	1960	1875	1790	1944	1530	1460	1586	429.8	374	499.7	2401	2248	2556

CALLAO	a70.79	2220	1946	1816	2052	1588	1482	1674	632	546.1	738.2	2720	2485	2956
CALLAO	a80	2982	2130	1929	2301	1738	1573	1878	1244	1104	1409	3653	3281	4027
CUSCO	a0.9	354	4	4	4	0	0	0	354	354	354	425.9	425.9	425.9
CUSCO	a10.19	177	3	3	3	0	0	0	177	177	177	214	214	214
CUSCO	a20.29	247	8	8	8	-133.3	-306.4	-20.73	380.3	267.7	553.4	461.3	327.1	677.6
CUSCO	a30.39	319	18	18	18	0	0	0	319	319	319	398.2	398.2	398.2
CUSCO	a40.49	519	35	35	35	0	0	0	519	519	519	653.6	653.6	653.6
CUSCO	a50.59	789	89	89	89	0	0	0	789	789	789	1029	1029	1029
CUSCO	a60.69	1192	146	146	146	0	0	0	1192	1192	1192	1567	1567	1567
CUSCO	a70.79	1610	110	110	110	0	0	0	1610	1610	1610	2029	2029	2029
CUSCO	a80	2453	120	120	120	0	0	0	2453	2453	2453	3044	3044	3044
HUANCAVELICA	a0.9	141	1	1	1	0	0	0	141	141	141	173.3	173.3	173.3
HUANCAVELICA	a10.19	60	2	2	2	0	0	0	60	60	60	75.34	75.34	75.34
HUANCAVELICA	a20.29	76	2	2	2	0	0	0	76	76	76	94.89	94.89	94.89
HUANCAVELICA	a30.39	79	7	7	7	0	0	0	79	79	79	103.6	103.6	103.6

HUANCAVELICA	a40.49	152	19	19	19	0	0	0	152	152	152	204.8	204.8	204.8
HUANCAVELICA	a50.59	232	117.5	58.58	158.8	96.17	47.11	129.1	135.8	102.9	184.9	283.6	184.4	384.7
HUANCAVELICA	a60.69	354	210.6	135.4	264.3	172.3	110	215.4	181.7	138.6	244	432.7	304.8	562.6
HUANCAVELICA	a70.79	548	248	122.9	340.8	202.9	99.72	278	345.1	270	448.3	669.8	452.9	888.7
HUANCAVELICA	a80	782	20	20	20	0	0	0	782	782	782	975.8	975.8	975.8
HUANUCO	a0.9	187	0	1	1	0	0	0	187	187	187	287	288	288
HUANUCO	a10.19	71	4	4	4	0	0	0	71	71	71	113	113	113
HUANUCO	a20.29	125	10	10	10	0	0	0	125	125	125	201.8	201.8	201.8
HUANUCO	a30.39	167	18	18	18	0	0	0	167	167	167	274.3	274.3	274.3
HUANUCO	a40.49	268	35	35	35	0	0	0	268	268	268	446.3	446.3	446.3
HUANUCO	a50.59	411	227	83	326.2	147.9	54.18	211.9	263.1	199.1	356.8	630.7	388.6	873.8
HUANUCO	a60.69	670	390.4	231.7	512.5	254.4	150.3	333.3	415.6	336.7	519.7	1028	748.4	1310
HUANUCO	a70.79	909	340.2	127	517.7	221.7	74.92	336.7	687.3	572.3	834.1	1395	1005	1798
HUANUCO	a80	1232	103	103	103	0	0	0	1232	1232	1232	1994	1994	1994
ICA	a0.9	170	3	3	3	0	0	0	170	170	170	173.2	173.2	173.2

ICA	a10.19	52	2	2	2	-26.27	-67.82	-1.19	78.27	53.19	119.8	80.38	55.27	122
ICA	a20.29	164	15	15	15	0	0	0	164	164	164	179.2	179.2	179.2
ICA	a30.39	256	51	51	51	0	0	0	256	256	256	307.4	307.4	307.4
ICA	a40.49	527	300.7	230.3	351.3	300.2	229	349.8	226.8	177.2	298	527.8	407.8	649.7
ICA	a50.59	968	604.4	516.4	671.7	603.5	514.7	669.7	364.5	298.3	453.3	969.4	815.2	1126
ICA	a60.69	1468	1054	962.9	1126	1052	960.5	1123	415.7	344.7	507.5	1470	1308	1634
ICA	a70.79	1638	903.1	767.6	1013	901.8	765.4	1011	736.2	627.4	872.6	1640	1396	1887
ICA	a80	2520	1100	879.2	1285	1098	877	1282	1422	1238	1643	2524	2119	2930
JUNIN	a0.9	372	7	7	7	-142.7	-313.6	-20.37	514.7	392.4	685.6	612.7	468.8	813.8
JUNIN	a10.19	151	5	5	5	0	0	0	151	151	151	182.7	182.7	182.7
JUNIN	a20.29	219	13	13	13	0	0	0	219	219	219	270.7	270.7	270.7
JUNIN	a30.39	322	25	25	25	0	0	0	322	322	322	403.9	403.9	403.9
JUNIN	a40.49	554	220.1	91	324	187	64.69	274.5	367	279.5	489.3	652	419.9	899.9
JUNIN	a50.59	947	437.6	249.8	579.1	371.9	211.4	491.3	575.1	455.7	735.6	1114	786.1	1445

JUNIN	a60.69	1393	608.5	366.2	797.8	517.1	310.3	677	875.9	716	1083	1639	1209	2072
JUNIN	a70.79	1805	655.7	406.7	863.2	557.2	344.7	732.6	1248	1072	1460	2124	1669	2582
JUNIN	a80	2745	443	164	745	376.4	80.61	632.2	2369	2113	2664	3230	2650	3881
LA LIBERTAD	a0.9	334	5	5	5	0	0	0	334	334	334	404.4	404.4	404.4
LA LIBERTAD	a10.19	143	7	7	7	0	0	0	143	143	143	178	178	178
LA LIBERTAD	a20.29	297	26	26	26	0	0	0	297	297	297	381.2	381.2	381.2
LA LIBERTAD	a30.39	409	67	67	67	0	0	0	409	409	409	556.1	556.1	556.1
LA LIBERTAD	a40.49	743	379.1	243.9	482.1	317	203.1	402.3	426	340.7	539.9	888.5	651.3	1128
LA LIBERTAD	a50.59	1441	1017	860	1140	850.6	718.3	952.6	590.4	488.4	722.7	1723	1444	2004
LA LIBERTAD	a60.69	2322	1651	1446	1818	1380	1209	1519	941.6	802.8	1113	2777	2406	3149
LA LIBERTAD	a70.79	2875	1810	1539	2036	1514	1286	1701	1361	1174	1589	3438	2942	3936
LA LIBERTAD	a80	4055	1267	816.2	1658	1060	681.7	1386	2995	2669	3373	4849	4008	5692
LAMBAYEQUE	a0.9	81	3	3	3	0	0	0	81	81	81	155.4	155.4	155.4
LAMBAYEQUE	a10.19	29	2	2	2	0	0	0	29	29	29	56.55	56.55	56.55

LAMBAYEQUE	a20.29	90	70.23	25	105.6	37.33	4.082	55.63	52.67	34.37	85.92	169.3	89.66	267.3
LAMBAYEQUE	a30.39	176	221.8	179.6	248.9	117.9	94.97	131.8	58.09	44.22	81.03	331.1	262.8	401.3
LAMBAYEQUE	a40.49	367	614.7	581.7	634.4	326.8	308.7	336.7	40.24	30.27	58.3	690.4	638.6	744.1
LAMBAYEQUE	a50.59	734	1287	1259	1306	684.2	668.9	693.8	49.83	40.25	65.06	1381	1335	1428
LAMBAYEQUE	a60.69	1230	2138	2095	2167	1136	1113	1151	93.66	78.56	117	2314	2242	2387
LAMBAYEQUE	a70.79	1193	2078	2036	2107	1105	1082	1120	88.47	73.43	111.2	2244	2174	2316
LAMBAYEQUE	a80	1298	2118	2033	2175	1126	1080	1156	171.8	142.4	217.8	2442	2301	2585
LIMA	a0.9	1373	44	44	44	0	0	0	1373	1373	1373	1994	1994	1994
LIMA	a10.19	482	34	34	34	0	0	0	482	482	482	718.4	718.4	718.4
LIMA	a20.29	1297	142	142	142	0	0	0	1297	1297	1297	1984	1984	1984
LIMA	a30.39	2632	1817	1584	2018	1279	1115	1421	1353	1211	1517	3737	3304	4172
LIMA	a40.49	5421	5417	5157	5642	3815	3631	3973	1606	1448	1790	7697	7213	8184
LIMA	a50.59	10554	11497	11122	11822	8097	7832	8325	2457	2229	2722	14986	14287	15687
LIMA	a60.69	17126	18590	18002	19104	13092	12678	13453	4034	3673	4448	24318	23218	25420

LIMA	a70.79	19325	18625	17825	19338	13117	12552	13618	6208	5707	6773	27440	25928	28954
LIMA	a80	27139	19993	18830	21068	14080	13260	14836	13059	12303	13879	38536	36299	40775
LORETO	a0.9	275	6	6	6	-257.4	-479.2	-106.7	532.4	381.7	754.2	899.9	647	1272
LORETO	a10.19	85	11	11	11	0	0	0	85	85	85	153.7	153.7	153.7
LORETO	a20.29	152	20	20	20	0	0	0	152	152	152	275.2	275.2	275.2
LORETO	a30.39	253	187.1	107.9	242.1	111.4	63.65	143.6	141.6	109.4	189.4	424.8	291.6	560.1
LORETO	a40.49	389	393.1	319.9	447	234.1	189.9	265.6	154.9	123.4	199.1	653.2	527.1	781.3
LORETO	a50.59	615	787.8	729.6	831.3	469.2	433.9	494.5	145.8	120.5	181.1	1033	931.9	1135
LORETO	a60.69	958	1322	1252	1373	787.3	744.8	817.3	170.7	140.7	213.2	1609	1488	1731
LORETO	a70.79	932	1205	1115	1271	717.5	663.4	756.2	214.5	175.8	268.6	1565	1410	1722
LORETO	a80	783	863.5	747.9	949.8	514.3	444.8	565.1	268.7	217.9	338.2	1315	1114	1518
MADRE DE DIOS	a0.9	92	1	1	1	0	0	0	92	92	92	93.76	93.76	93.76
MADRE DE DIOS	a10.19	21	0	1	1	0	0	0	21	21	21	21.17	22.17	22.17
MADRE DE DIOS	a20.29	79	2	2	2	0	0	0	79	79	79	81.65	81.65	81.65

MADRE DE DIOS	a30.39	92	7	7	7	0	0	0	92	92	92	99.76	99.76	99.76
MADRE DE DIOS	a40.49	117	21	21	21	0	0	0	117	117	117	139	139	139
MADRE DE DIOS	a50.59	172	77.29	36.72	104.6	76.66	35.43	102.8	95.34	69.21	136.6	173.4	106.5	242.3
MADRE DE DIOS	a60.69	191	87.3	42	116.8	86.59	41.67	114.9	104.4	76.13	149.3	192.6	118.8	267.4
MADRE DE DIOS	a70.79	168	78.26	36.29	105.7	77.62	35	103.9	90.38	64.12	133	169.4	100.9	239.8
MADRE DE DIOS	a80	146	73.99	44.17	94.35	73.39	42.82	92.58	72.61	53.42	103.2	147.2	98.03	198.4
MOQUEGUA	a0.9	21	2	2	2	0	0	0	21	21	21	26.75	26.75	26.75
MOQUEGUA	a10.19	10	5.654	4.706	7.474	4.798	3.145	5.494	5.202	4.506	6.855	11.78	10.02	15.55
MOQUEGUA	a20.29	39	2	2	2	0	0	0	39	39	39	47.96	47.96	47.96
MOQUEGUA	a30.39	33	4	4	4	0	0	0	33	33	33	42.89	42.89	42.89
MOQUEGUA	a40.49	90	60.11	34.77	75.52	51.01	28.66	63.23	38.99	26.77	61.34	106.1	66.32	147.8
MOQUEGUA	a50.59	173	135.9	101.2	158.1	115.3	85.02	133.3	57.72	39.68	87.98	203.9	148	261.8
MOQUEGUA	a60.69	278	201	128.3	245.2	170.6	108	207.2	107.4	70.8	170	327.6	211.7	445.5
MOQUEGUA	a70.79	380	236.9	125.5	305.4	201.1	105.6	258.3	178.9	121.7	274.4	447.8	268.9	628.7

MOQUEGUA	a80	506	185.6	52	285.8	157.5	38.27	241.7	348.5	264.3	467.7	596.3	363.5	837
PASCO	a0.9	91	1	1	1	0	0	0	91	91	91	146.1	146.1	146.1
PASCO	a10.19	28	1	1	1	0	0	0	28	28	28	45.63	45.63	45.63
PASCO	a20.29	45	5	5	5	0	0	0	45	45	45	76.73	76.73	76.73
PASCO	a30.39	58	5	5	5	0	0	0	58	58	58	97.45	97.45	97.45
PASCO	a40.49	83	11	11	11	-43.2	-110	-1.745	126.2	84.74	193	212.2	146.1	318.7
PASCO	a50.59	152	126.8	76.45	160.9	79.57	47.33	100.3	72.43	51.66	104.7	242.3	158.8	327.8
PASCO	a60.69	220	142.3	64.38	196.9	89.26	39.76	122.9	130.7	97.12	180.2	350.7	219.2	484.2
PASCO	a70.79	245	22	22	22	0	0	0	245	245	245	412.5	412.5	412.5
PASCO	a80	293	28	28	28	0	0	0	293	293	293	495.1	495.1	495.1
PIURA	a0.9	301	17	17	17	-139.7	-307.6	-24.35	440.7	325.3	608.6	680.6	506.9	933.4
PIURA	a10.19	91	9	9	9	0	0	0	91	91	91	146	146	146
PIURA	a20.29	219	17	17	17	0	0	0	219	219	219	346.8	346.8	346.8
PIURA	a30.39	362	299.9	218.5	358	199.1	144.4	237.1	162.9	124.9	217.6	545.1	406.6	685.7
PIURA	a40.49	742	836.1	756.2	895.1	555.2	501.5	593.8	186.8	148.2	240.5	1117	979.4	1257

PIURA	a50.59	1386	1599	1500	1678	1062	995.6	1114	324	272.2	390.4	2087	1910	2266
PIURA	a60.69	2446	2789	2628	2921	1852	1745	1939	593.6	506.9	701.2	3683	3392	3977
PIURA	a70.79	2512	2613	2414	2776	1735	1603	1843	777	669.4	909.4	3783	3422	4145
PIURA	a80	3251	2437	2078	2741	1619	1380	1819	1632	1432	1871	4896	4234	5559
PUNO	a0.9	290	4	4	4	-169.9	-320.3	-61.31	459.9	351.3	610.3	637.4	487.8	844.5
PUNO	a10.19	129	2	2	2	0	0	0	129	129	129	179.7	179.7	179.7
PUNO	a20.29	230	12	12	12	0	0	0	230	230	230	328.8	328.8	328.8
PUNO	a30.39	282	10	10	10	0	0	0	282	282	282	398.4	398.4	398.4
PUNO	a40.49	486	48	48	48	0	0	0	486	486	486	717.3	717.3	717.3
PUNO	a50.59	788	73	73	73	0	0	0	788	788	788	1158	1158	1158
PUNO	a60.69	1128	107	107	107	0	0	0	1128	1128	1128	1660	1660	1660
PUNO	a70.79	1550	404.2	96	690.6	293.5	34.95	500.7	1257	1049	1515	2135	1541	2777
PUNO	a80	2133	51	51	51	0	0	0	2133	2133	2133	2989	2989	2989
SAN MARTIN	a0.9	190	10	10	10	-131	-286	-33.63	321	223.6	476	486.6	342	716.7

SAN MARTIN	a10.19	69	3	3	3	0	0	0	69	69	69	105.4	105.4	105.4
SAN MARTIN	a20.29	153	14	14	14	0	0	0	153	153	153	241.2	241.2	241.2
SAN MARTIN	a30.39	207	40	40	40	0	0	0	207	207	207	347.3	347.3	347.3
SAN MARTIN	a40.49	322	178.7	83	257.2	120.3	43.98	172.6	201.7	149.4	278	478.1	304.8	670
SAN MARTIN	a50.59	522	380.4	253.3	471.6	256.2	170	316.9	265.8	205.1	352	775	557.8	994.2
SAN MARTIN	a60.69	744	489	304.7	624.2	329.3	204.6	419.8	414.7	324.2	539.4	1105	786.1	1425
SAN MARTIN	a70.79	796	308.1	146	483.4	207.5	51.86	324.9	588.5	471.1	744.1	1182	845.4	1588
SAN MARTIN	a80	1207	424	157	674.1	285.6	69.06	453.4	921.4	753.6	1138	1792	1276	2364
TACNA	a0.9	39	0	1	1	0	0	0	39	39	39	48.97	49.97	49.97
TACNA	a10.19	18	1	1	1	0	0	0	18	18	18	23.6	23.6	23.6
TACNA	a20.29	49	4	4	4	0	0	0	49	49	49	65.53	65.53	65.53
TACNA	a30.39	77	6	6	6	0	0	0	77	77	77	102.7	102.7	102.7
TACNA	a40.49	131	24	24	24	0	0	0	131	131	131	188.5	188.5	188.5
TACNA	a50.59	225	118.7	45	180.3	94.51	7.482	142.8	130.5	82.2	217.5	282.5	148.2	453.4

TACNA	a60.69	375	222	73	304	176.8	70.83	241.3	198.2	133.7	304.2	470.9	240.8	685.9
TACNA	a70.79	396	163.4	75	258	130.1	15.67	204.7	265.9	191.3	380.3	497.2	315.2	735.5
TACNA	a80	444	154	42	252.2	122.6	8.917	200.1	321.4	243.9	435.1	557.5	348.3	798.5
TUMBES	a0.9	58	0	1	1	0	0	0	58	58	58	66.68	67.68	67.68
TUMBES	a10.19	20	2	2	2	0	0	0	20	20	20	24.99	24.99	24.99
TUMBES	a20.29	47	1	1	1	0	0	0	47	47	47	55.03	55.03	55.03
TUMBES	a30.39	80	31.38	12	48.73	27.3	5.14	41.52	52.7	38.48	74.86	91.97	56.23	134.8
TUMBES	a40.49	116	60.49	31.38	81.02	52.62	26.43	69.61	63.38	46.39	89.57	133.4	84.7	184
TUMBES	a50.59	231	185	157.6	204.9	160.9	136.2	177.3	70.1	53.67	94.79	265.6	219.3	313.8
TUMBES	a60.69	366	313.9	282.8	336.7	273.1	245.1	292.1	92.91	73.94	120.9	420.7	367.8	475.7
TUMBES	a70.79	354	226.2	169.4	267.5	196.8	146.5	231.8	157.2	122.2	207.5	407	309.8	506.1
TUMBES	a80	505	253.5	170.2	316.1	220.5	147.1	274.1	284.5	230.9	357.9	580.5	435.6	727.4
UCAYALI	a0.9	137	9	9	9	-76	-188.7	-6.837	213	143.8	325.7	303.4	207.8	459.1
UCAYALI	a10.19	57	7	7	7	0	0	0	57	57	57	85.77	85.77	85.77
UCAYALI	a20.29	135	10	10	10	0	0	0	135	135	135	196.6	196.6	196.6

UCAYALI	a30.39	170	104	53.17	138.7	75.23	37.75	99.62	94.77	70.38	132.2	234.9	150.4	321.4
UCAYALI	a40.49	213	156	104.8	190.6	112.9	75.13	137.2	100.1	75.79	137.9	294.4	209.6	381.2
UCAYALI	a50.59	422	359	300	401.4	259.8	216.3	289.7	162.2	132.3	205.7	583.2	482.8	685.6
UCAYALI	a60.69	596	571.2	511.4	616.5	413.3	369.4	445.4	182.7	150.6	226.6	823.7	719.6	929.7
UCAYALI	a70.79	653	635.6	571.7	682.7	459.9	413	493.3	193.1	159.7	240	902.4	792.4	1014
UCAYALI	a80	649	455.8	341.5	541.1	329.8	246.4	390.8	319.2	258.2	402.6	896.9	698.3	1098
Total	-	211649	142875	127163	155739	99814	85605	110738	111835	100911	126044	292230	262000	324023

Proportion total excess deaths per region

Table 8: Proportion total excess deaths per region

Departamento	suma	prop
AMAZONAS	NA	NA
ANCASH	4136	4.05
APURIMAC	159	0.1557
AREQUIPA	4547	4.453
AYACUCHO	378	0.3702
CAJAMARCA	2105	2.061
CALLAO	7911	7.748
CUSCO	533	0.522
HUANCAVELICA	627.2	0.6143
HUANUCO	NA	NA
ICA	4032	3.949
JUNIN	2415	2.365
LA LIBERTAD	6229	6.101
LAMBAYEQUE	8532	8.356
LIMA	76158	74.58

LORETO	4795	4.696
MADRE DE DIOS	NA	NA
MOQUEGUA	833.1	0.8159
PASCO	342.1	0.3351
PIURA	10618	10.4
PUNO	711.2	0.6965
SAN MARTIN	1847	1.809
TACNA	NA	NA
TUMBES	NA	NA
UCAYALI	2308	2.26

Population 2020 per region

Table 8: Population 2020 per region

Departamento	pop.INEI
MADRE DE DIOS	153164
MOQUEGUA	189701
TUMBES	251363
PASCO	314677
TACNA	362331
AMAZONAS	427202
APURIMAC	467707
HUANCAVELICA	511794
UCAYALI	523086
AYACUCHO	725649
ICA	825042
HUANUCO	888845
SAN MARTIN	894564
CALLAO	1081491
LORETO	1085375
ANCASH	1177080
LAMBAYEQUE	1309731
CUSCO	1352476
AREQUIPA	1358108
JUNIN	1398361
PUNO	1485328
CAJAMARCA	1544325
PIURA	1914346

LA LIBERTAD	1973446
LIMA	10609166

Appendix 2

Estimations based on mortality baselines and differences - robustness check

The overall excess mortality estimates obtained from the baseline-approach model are 9.78% below the estimates obtained using the PAF model. The age distribution of mortality is highly consistent in both models. However, most differences between both estimates are concentrated in the oldest age groups. Differences between both approaches are mainly due to the inclusion of the upper confidence interval are in the final count.

Table 8: Estimations based on mortality baselines and differences

Age.group	Epi-weeks	Positive-Excess	All-Excess
0-9	0	72.85	-519.6
10-19	19.01	174.3	108.5
20-29	49.87	207.7	-135.3
30-39	1591	1719	1595
40-49	6792	6834	6803
50-59	14059	14130	14085
60-69	23561	23623	23611
70-79	22807	22912	22885
80+	21169	21357	21357
Grand Total	90048	91030	89790

Note: Epi-weeks (column 2) includes excess deaths during periods in which the observed mortality was above the upper uncertainty interval; Positive-Excess (column 3) includes excess in which the observed mortality was above the baseline; and All-Excess (column 4) includes both positive and negative excess deaths.

Appendix 3

Comparison with other studies in Peru

A simple comparison of registered deaths in Peru for months April to June of 2020 and corresponding periods in 2017-19 estimates 36,322 excess deaths.[47] It does not include non-registered deaths or take improvements in data registration into account. Applying our approach to this time period gives an estimate of 35,461 (CI 95% 32,425-37,803) registered deaths which climbs to 49,648 (CI 95% 48,037-51,034). A similar comparison between 1 January to 12 July 2020 and the corresponding periods in 2017-19 shows excess 46,863 deaths, compared to 50,534 (CI 95% 44,448-55,582), applying our approach to the same period.[48] This second study includes 2,000 excess deaths before March 2020, which cannot be attributed to the COVID-19 pandemic. A study of Lima metropolitan region finds an excess of 20,093 non-violent deaths for the first 24 weeks of 2020.[49] This is above to our own estimate based on registered deaths in Lima over the same period: 14,659 (CI 95% 13,579 – 15,609). Adding unregistered deaths increases this to 20149 (CI 95% 18,839-21,323).