

Excess total mortality during the Covid-19 pandemic in Italy: updated estimates indicate persistent excess in recent months

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ABSTRACT

Background: *New releases of daily mortality data are available in Italy; the last containing data up to 31 January 2022. This study revises previous estimates of the excess mortality in Italy during the Covid-19 pandemic. Methods:* Excess mortality was estimated as the difference between the number of registered deaths and the expected deaths. Expected deaths in March–December 2020, January–December 2021 and January 2022 were estimated separately by sex, through an over-dispersed Poisson regression model using mortality and population data for the period 2011–2019. The models included terms for calendar year, age group, a smooth function of week of the year and the natural logarithm of the population as offset term. **Results:** We estimated 99,334 excess deaths (+18.8%) between March and December 2020, 61,808 deaths (+9.5%) in 2021 and 4143 deaths (+6.1%) in January 2022. Over the whole pandemic period, 13,039 excess deaths (+10.2%) were estimated in the age group 25–64 years with most of the excess observed among men [10,025 deaths (+12.6%) among men and 3014 deaths (+6.3%) among women]. **Conclusions:** Up to 31 January 2022, over 165 thousand excess deaths were estimated in Italy, of these about 8% occurred among the working age population. Despite high vaccination uptake, excess mortality is still observed in recent months.

INTRODUCTION

Excess in total mortality is the most valid indicator of the impact of the Covid-19 pandemic on the population, since it captures not only the deaths attributed to Covid-19 but also those related to the disruption of the health system. Since June 2020, the Italian National Institute of Statistics has provided daily mortality data by sex, age and municipality of residence during the pandemic period along with historic data [1]. These data were used by several research groups to estimate the excess total

mortality in Italy [2–7]. However, given the preliminary nature of the data due to possible delay in registration, the number of deaths changes when more updated data become available. In a previous study [6], we used data collected up to 31 August 2021 and we estimated an excess of around 35,000 deaths between January and August 2021, which given the epidemiological trend at that time would become 40 thousand by the end of the year. In a new data release which covers the whole year, the number of deaths registered in the first 8 months of 2021 was revised upward by 10,000 thousand deaths [1]. Thus,

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in this work we provided a revision of the previous published data on excess mortality in Italy in 2021 disaggregated by sex and age groups.

METHODS

The work is based on daily mortality data from 1 January 2011 to 31 January 2022 (the last day of available mortality data) and resident population data of each year of the same period. The data are of public domain and were downloaded from the repositories of the National Institute of Statistics [1, 8]. Population data for 2022 was not yet available and it was estimated from historic data (2011-2021) using a Poisson regression model including age groups, calendar years and age group-by-calendar year interaction as predictors.

The excesses total mortality in March-December 2020, the whole 2021 and in January 2022 were computed through the difference between the number of deaths registered in the three periods and the expected deaths in the same periods, and also quan-

tified as percent relative difference compared to the expected deaths.

Expected deaths were estimated separately by sex, through over-dispersed Poisson regression models using mortality and population data for the period 2011-2019 (before the Covid-19 outbreak). The model included a linear term for calendar year (to account for temporal trends in mortality), age groups (to capture the demographic changes over the period), a smooth function of week of the year (to capture seasonal variations), and the natural logarithm of the population as offset term. A natural spline was used as a smooth function with number of knots chosen on the basis of the quasi-Akaike Information Criterion (QAIC) [9]. Up to 10 equally spaced knots were tested.

Excess deaths were provided with 95% confidence intervals (CI) at all ages and by the age groups 0-24, 25-64, 65-79 and ≥ 80 years. We defined the working population as individuals aged 25-64 years, not including individuals who may still be in education, and those who are retired.

Table 1. Observed, expected deaths and excess total deaths in Italy from March to December 2020, disaggregated by sex and age group

Sex	Age group	Observed deaths	Expected deaths ¹	Δ (observed - expected deaths)			Percentage difference		
				Estimate	95% LCL	95% UCL	Estimate	95% LCL	95% UCL
Women	0-24	892	955	-63	-108	-21	-6.6	-11.3	-2.2
	25-64	21,942	20,367	1575	1325	1819	7.7	6.5	8.9
	65-79	60,037	51,298	8739	8398	9075	17.0	16.4	17.7
	80+	238,484	201,930	36,554	35,451	37,657	18.1	17.6	18.6
	All ages	321,355	274,550	46,805	45,066	48,530	17.0	16.4	17.7
Men	0-24	1442	1634	-192	-252	-139	-11.8	-15.4	-8.5
	25-64	38,778	33,933	4845	4515	5170	14.3	13.3	15.2
	65-79	96,248	77,009	19,239	18,783	19,695	25.0	24.4	25.6
	80+	170,234	141,597	28,637	27,819	29,446	20.2	19.6	20.8
	All ages	306,702	254,173	52,529	50,865	54,172	20.7	20.0	21.3
All sexes	0-24	2334	2589	-255	-360	-160	-9.8	-13.9	-6.2
	25-64	60,720	54,300	6420	5840	6989	11.8	10.8	12.9
	65-79	156,285	128,307	27,978	27,181	28,770	21.8	21.2	22.4
	80+	408,718	343,527	65,191	63,270	67,103	19.0	18.4	19.5
	All ages	628,057	528,723	99,334	95,931	102,702	18.8	18.1	19.4

¹ Estimated from 2011-2019 mortality and population data, separately by sex, through an over-dispersed Poisson regression model including a linear term for calendar year (to account for the temporal improvement in mortality), age groups as categorical variable (to capture the demographic changes over the period), a smooth function of week of the year with 7 equally spaced knots (to capture seasonal variations), and the natural logarithm of the population as offset. Values were rounded up to the smallest integer. LCL: Lower Confidence Limit; UCL: Upper Confidence Limit.

RESULTS

Table 1 shows the excess deaths computed for March-December 2020 by sex and age groups. Corresponding figures for the whole 2021 and for January 2022 are reported in Table 2 and Table 3, respectively.

Between March and December 2020, we estimated an excess total mortality of 99,334 deaths (+18.8%), mainly occurring at ages ≥ 65 years (93,169 deaths), while 6420 excess deaths (+11.8%) were estimated at working ages. In 2021, the excess was 61,808 deaths (+9.5%) with 55,324 deaths registered at ages ≥ 65 and 6643 deaths (+10%) estimated at working ages. In January 2022, 4143 excess deaths (+6.1%) were estimated in the whole population based on provisional data, while no excess was detected among the working age population. Excess mortality was consistently higher among men than women during all the periods considered.

In the months where Omicron was the main circulating SARS-CoV-2 variant (December

2020-January 2021), 21,338 excess deaths were estimated (+8.4%), though part of the excess is likely attributable to the Delta variant.

Figure 1 shows the trend in the difference between observed and expected deaths during the whole pandemic period by month, sex and age groups. For the age group 25-64, four peaks in the excess deaths were identified corresponding to the months of March 2020, November 2020, April 2021 and August-September 2021. For older ages, excess deaths peaked in March 2020, November 2020 and March-April 2021. The highest excesses were observed in March and November 2020 with values above 60%.

Figure 2 shows a comparison between the estimated excess total mortality, the number of Covid-19 deaths and the number of cases registered by month from the outbreak of the pandemic up to January 2022. During the outbreak of the pandemic (March-April 2020), our estimates of excess mortality suggest an important under-registration of Covid-19 deaths, which was observed also during

Table 2. Observed, expected deaths and excess total deaths in Italy in 2021, disaggregated by sex and age group

Sex	Age group	Observed deaths	Expected deaths ¹	Δ (observed - expected deaths)			Percentage difference		
				Estimate	95% LCL	95% UCL	Estimate	95% LCL	95% UCL
Women	0-24	1122	1147	-25	-79	27	-2.2	-6.9	2.4
	25-64	26,727	25,090	1637	1327	1942	6.5	5.3	7.7
	65-79	70,503	62,182	8321	7897	8743	13.4	12.7	14.1
	80+	265,176	248,663	16,513	15,084	17,932	6.6	6.1	7.2
	All ages	363,528	337,082	26,446	24,229	28,644	7.8	7.2	8.5
Men	0-24	1817	1951	-134	-204	-68	-6.9	-10.5	-3.5
	25-64	46,262	41,256	5006	4601	5410	12.1	11.2	13.1
	65-79	107,434	92,338	15,096	14,526	15,662	16.3	15.7	17.0
	80+	189,994	174,600	15,394	14,339	16,440	8.8	8.2	9.4
	All ages	345,507	310,145	35,362	33,262	37,444	11.4	10.7	12.1
All sexes	0-24	2939	3098	-159	-283	-41	-5.1	-9.1	-1.3
	25-64	72,989	66,346	6643	5928	7352	10.0	8.9	11.1
	65-79	177,937	154,520	23,417	22,423	24,405	15.2	14.5	15.8
	80+	455,170	423,263	31,907	29,423	34,372	7.5	7.0	8.1
	All ages	709,035	647,227	61,808	57,491	66,088	9.5	8.9	10.2

¹ Estimated from 2011-2019 mortality and population data, separately by sex, through an over-dispersed Poisson regression model including a linear term for calendar year (to account for the temporal improvement in mortality), age groups as categorical variable (to capture the demographic changes over the period), a smooth function of week of the year with 7 equally spaced knots (to capture seasonal variations), and the natural logarithm of the population as offset. Values were rounded up to the smallest integer. LCL: Lower Confidence Limit; UCL: Upper Confidence Limit.

Table 3. Observed, expected deaths and excess total deaths in Italy in January 2022, disaggregated by sex and age group

Sex	Age group	Observed deaths	Expected deaths ¹	Δ (observed - expected deaths)			Percentage difference		
				Estimate	95% LCL	95% UCL	Estimate	95% LCL	95% UCL
Women	0-24	89	116	-27	-33	-22	-23.3	-28.4	-19.0
	25-64	2389	2587	-198	-231	-166	-7.7	-8.9	-6.4
	65-79	6814	6528	286	238	334	4.4	3.6	5.1
	80+	27,760	26,747	1013	845	1180	3.8	3.2	4.4
	All ages	37,052	35,978	1074	819	1326	3.0	2.3	3.7
Men	0-24	174	191	-17	-24	-11	-8.9	-12.6	-5.8
	25-64	4261	4087	174	133	216	4.3	3.3	5.3
	65-79	10,516	9406	1110	1047	1173	11.8	11.1	12.5
	80+	19,888	18,086	1802	1682	1920	10.0	9.3	10.6
	All ages	34,839	31,770	3069	2838	3298	9.7	8.9	10.4
All sexes	0-24	263	307	-44	-57	-33	-14.3	-18.6	-10.7
	25-64	6650	6674	-24	-98	50	-0.4	-1.5	0.7
	65-79	17,330	15,934	1396	1285	1507	8.8	8.1	9.5
	80+	47,648	44,833	2815	2527	3100	6.3	5.6	6.9
	All ages	71,891	67,748	4143	3657	4624	6.1	5.4	6.8

¹ Estimated from 2011-2019 mortality and population data, separately by sex, through an over-dispersed Poisson regression model including a linear term for calendar year (to account for the temporal improvement in mortality), age groups as categorical variable (to capture the demographic changes over the period), a smooth function of week of the year with 7 equally spaced knots (to capture seasonal variations), and the natural logarithm of the population as offset. Values were rounded up to the smallest integer.

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the mortality peak of November 2020.

In January-February 2021, Covid-19 deaths exceeded excess total mortality, while the two values got closer thereafter, although excess total deaths were always slightly higher than the Covid-19 deaths in the most recent months. In January 2022, when the spread of the Omicron variant led to a surge in the number of cases (close to 5 million of cases registered), less than 5000 excess deaths were estimated, while about 9000 Covid-19 deaths were registered.

DISCUSSION

This study provides updated estimates of the excess mortality in Italy during the Covid-19 pandemic. We estimated more than 165,000 excess deaths up to January 2022, of these 13,000 were among the working-age population.

The excess deaths observed among the working-

age population represents a small share of the total excess and a minor contributor to the loss in life expectancy at birth (-1.25 years among men and -1 year among women) documented in Italy in 2020 as a consequence of the excess mortality due to the Covid-19 [10]. However, it has important implications not only for individuals and families but also for the whole society in terms of loss of productivity resulting from workforce depletion due to premature deaths.

Our results also highlight the crucial role of the successful vaccination campaign in the containment of further excesses in the second half of 2021. Indeed, the excess mortality observed in 2020 when vaccines were not available halved in 2021 (from +18.8 to +9.5%), despite the fact that the impact of vaccines was limited in the first part of 2021. At the beginning of July, about 60% of the eligible population had received one dose and 35% two doses of vaccine.

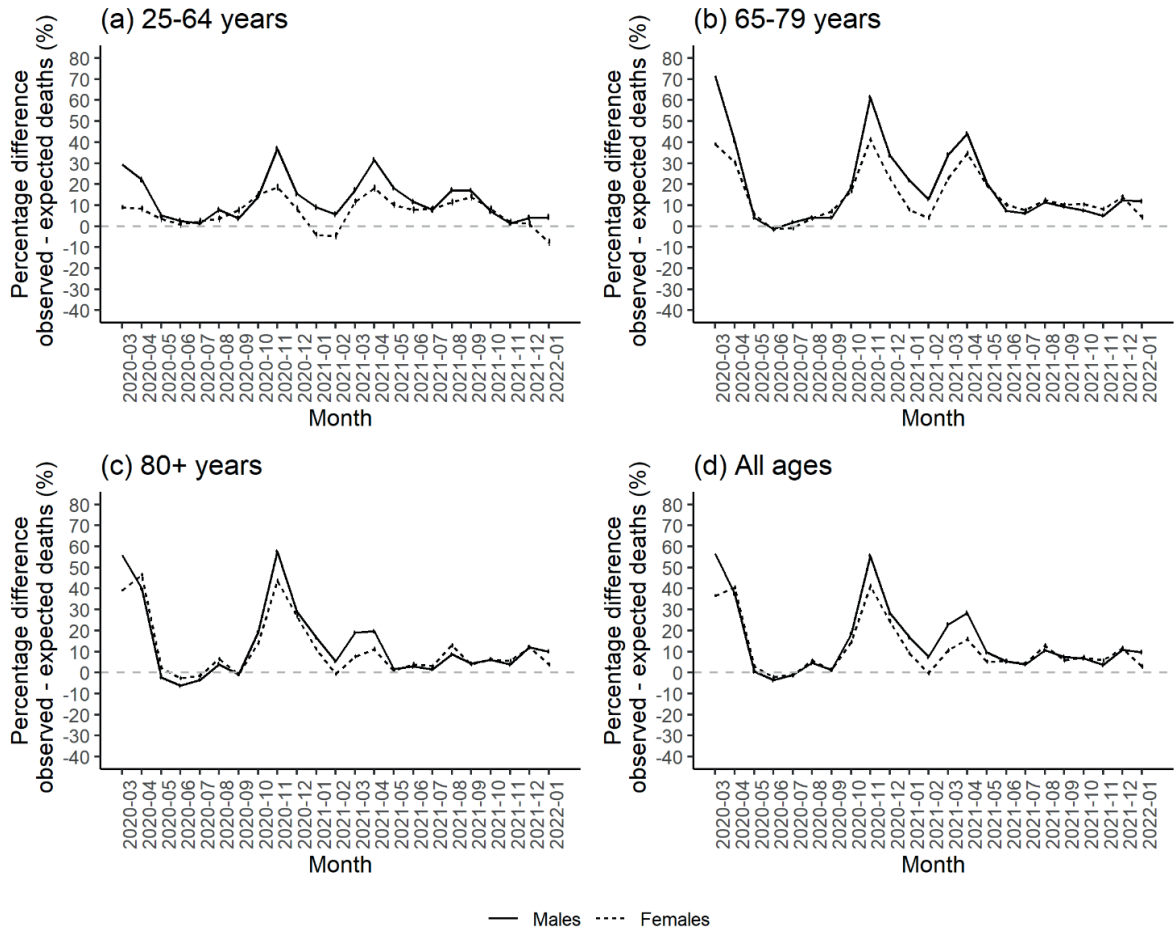


Figure 1. Monthly trend in percentage differences between observed and expected total deaths in Italy in the age group 25-64 (Panel a), 65-79 (Panel b), 80+ (Panel c) and at all ages (Panel d), by sex. Period: March 2020-January 2022.

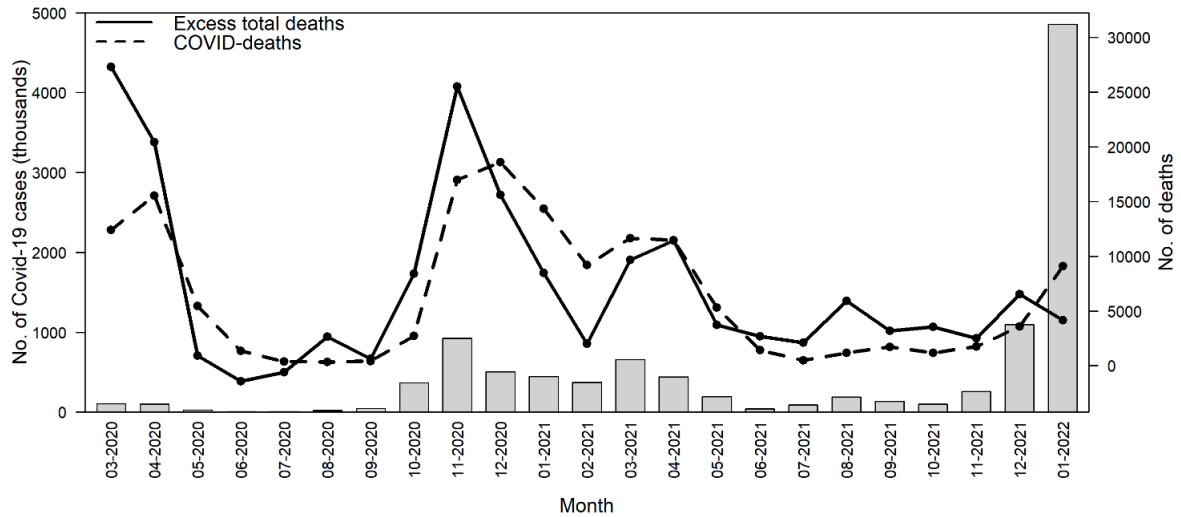


Figure 2. Number of Covid-19 cases (bars) registered in Italy between March 2020 and January 2022, estimated difference in total mortality and number of COVID deaths registered in the same period (lines).

Starting in mid-December 2021, the Omicron variant of SARS-CoV-2 caused a surge in the number of infections due to its high transmissibility and capacity to escape immunity provided by both prior infection and vaccination [11]. Almost 40% of the cases observed during the whole pandemic period were registered in a single month, even though the true circulation of the virus was likely higher than that estimated by surveillance data. Indeed, surveillance data mainly depend on test availability and indications, thus most asymptomatic and mild cases were left uncounted [12].

Thanks to the protection conferred by vaccines and the milder disease caused by Omicron as compared to other SARS-CoV-2 variants [13], the surge in the number of cases was not followed by an increase in the number of deaths. Indeed, lower risks of hospitalization due to severe Covid-19 and death have been reported for Omicron as compared to the Delta variant, thus indicating a lower case fatality rate of Omicron [14]. Although a 6% excess can still be observed in January 2022, despite almost 80% of the population aged 5 years and over received two doses and 60% received three doses of the SARS-CoV-2 vaccine [15]. This indicates that even if Omicron infection generally causes a milder disease as compared to the original strain and previous variants of SARS-CoV-2 it can still be a deadly condition even in a population with high vaccine uptakes [13]. There was, however, no excess deaths in the working-age population. This confirms the less severe clinical pattern of Omicron vs Delta and previous variants, and indicates that most Omicron-related deaths are in the elderly frail population.

In January 2022 and in all the winter 2020-2021 there was no influenza in Italy. On average, 17 to 20,000 deaths are attributed to influenza and related syndromes each year in Italy. Thus, the real Covid-19-related excess death in January 2021 and 2022 is greater than the one registered.

Our results are based on provisional estimates provided by the National Institute of Statistics that may change when updated data are released, especially for the most recent months. Causes-of-death data during the pandemic period are not available, thus we could not separately quantify the excess mortality due to Covid-19 from that attributable to

non-Covid-19 causes. In this regard, a study based on the first two months of the pandemic in Italy (March-April 2020) found an 11% increase in mortality from non-Covid-19 deaths that reached 64% in Lombardy (the region most severely hit during the first wave of Covid-19) [16]. Important excesses were observed in mortality from non-respiratory causes including hypertensive, ischemic and cerebrovascular diseases, diabetes, dementia and Alzheimer's disease.

Our estimate of 160,000 deaths in 2020-2021 is greater than the figure of 137,402 Covid-19 deaths officially registered by the end of 2022 [15]. They are however substantially lower than the estimate of 259,000 excess deaths in 2020-2021 estimated by the Covid-19 Excess Mortality Collaborators (CEMC) using a Bayesian model [17]. The overestimate by the CEMC does not apply only to high-income countries, but also to middle-income ones, such as India, for which 4.07 million deaths were estimated as compared to 3.2 million of a nationally representative survey [18].

CONCLUSIONS

The availability of complete and timely data on total mortality in Italy allowed a close monitoring of the impact of the Covid-19 pandemic and of the effectiveness of vaccines and containment measures. These data are still important now that the Italian Government is leaving the state of emergency and relaxing several containment measures.

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REFERENCES

1. Istituto Nazionale di Statistica. Decessi e cause di morte: cosa produce l'Istat. Accessed March 28, 2022. <https://www.istat.it/it/archivio/240401>.
2. Islam N, Shkolnikov VM, Acosta RJ, 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. doi:10.1136/bmj.n1137.

3. Alicandro G, La Vecchia C, Remuzzi G, Gerli A, Centanni S. Excess mortality in Italy in 2020 by sex and age groups accounting for demographic changes and temporal trends in mortality. *Panminerva Med.* Published online 2021. doi:10.23736/s0031-0808.21.04397-4.
4. Gianicolo EAL, Russo A, Büchler B, Taylor K, Stang A, Blettner M. Gender specific excess mortality in Italy during the COVID-19 pandemic accounting for age. *Eur J Epidemiol.* Published online 2021. doi:10.1007/s10654-021-00717-9.
5. Konstantinoudis G, Cameletti M, Gómez-Rubio V, et al. Regional excess mortality during the 2020 COVID-19 pandemic in five European countries. *Nat Commun.* 2022;13(1). doi:10.1038/s41467-022-28157-3.
6. Alicandro G, Remuzzi G, Centanni S, Gerli A, Vecchia C La. Excess total mortality in 2021 in Italy was about one third of that observed in 2020. *Med Lav.* 2021;112(6):414-421. doi:10.23749/MDL.V112I6.12601.
7. Alicandro G, Remuzzi G, La Vecchia C. COVID-19 pandemic and total mortality in the first six months of 2020 in Italy. *Med del Lav.* 2020;111(5):351-353. doi:10.23749/mdl.v111i5.10786.
8. Istituto Nazionale di Statistica. Popolazione residente ricostruita - Anni 2002-2019. Accessed November 15, 2021. <http://dati.istat.it/?lang=it&SubSessionId=>
9. Burnham K, Anderson D. *Model Selection and Multi-model Inference.* Springer New York; 2004. doi:10.1007/b97636.
10. Aburto JM, Schöley J, Kashnitsky I, et al. Quantifying impacts of the COVID-19 pandemic through life-expectancy losses: a population-level study of 29 countries. *Int J Epidemiol.* 2022;51(1):63-74. doi:10.1093/IJE/DYAB207.
11. Karim SSA, Karim QA. Omicron SARS-CoV-2 variant: a new chapter in the COVID-19 pandemic. *Lancet.* 2021;398(10317):2126-2128. doi:10.1016/S0140-6736(21)02758-6.
12. Nattino G, Castiglioni S, Cereda D, et al. Association Between SARS-CoV-2 Viral Load in Wastewater and Reported Cases, Hospitalizations, and Vaccinations in Milan, March 2020 to November 2021. *Jama.* Published online April 1, 2022. doi:10.1001/jama.2022.4908.
13. Nealon J, Cowling BJ. Omicron severity: milder but not mild. *Lancet.* 2022;399(10323):412-413. doi:10.1016/S0140-6736(22)00056-3.
14. Nyberg T, Ferguson NM, Nash SG, et al. Comparative analysis of the risks of hospitalisation and death associated with SARS-CoV-2 omicron (B.1.1.529) and delta (B.1.617.2) variants in England: a cohort study. *Lancet.* 2022;399(10332):1303-1312. doi:10.1016/s0140-6736(22)00462-7.
15. Presidenza del Consiglio dei Ministri – Dipartimento di Protezione Civile. Andamento Nazionale Covid-19. Published 2022. Accessed March 21, 2022. <https://github.com/pcm-dpc/COVID-19>.
16. Grande E, Fedeli U, Pappagallo M, et al. Variation in Cause-Specific Mortality Rates in Italy during the First Wave of the COVID-19 Pandemic: A Study Based on Nationwide Data. *Int J Environ Res Public Health.* 2022;19(2). doi:10.3390/ijerph19020805.
17. Wang H, Paulson KR, Pease SA, et al. Estimating excess mortality due to the COVID-19 pandemic: a systematic analysis of COVID-19-related mortality, 2020–21. *Lancet.* 2022;0(0). doi:10.1016/s0140-6736(21)02796-3.
18. Jha P, Deshmukh Y, Tumbe C, et al. COVID mortality in India: National survey data and health facility deaths. *Science (80-).* 2022;375(6581):667-671. doi:10.1126/science.abm5154.