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Short-term mortality following COVID-19 vaccination in Bologna, Italy: a one-year study

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A B S T R A C T

The main objective of the study is to assess whether there is an increased risk of mortality in the days following the administration of COVID-19 vaccines in Bologna Health Authority in the first year of COVID-19 vaccination campaign. A secondary objective was to describe causes of deaths occurred in the days after vaccination. We conducted a retrospective observational study on all residents of Bologna Health Authority who received at least one COVID-19 vaccination dose from December 27, 2020 to December 31, 2021 and compared mortality in the 3, 7, 14, 30 days after vaccination (risk interval) with the mortality in the period of the same length (3, 7, 14 and 30 days) beyond the 30th day after the last dose of vaccination (control interval). The cohort included 717,538 people. The mortality rate was 2.24 per 100 person-years during the 30 days risk interval vs 2.72 in the control interval with an adjusted incidence rate ratio equal to 0.76 (95% CI: 0.70–0.83, p < 0.001). The risk of mortality is significantly lower (p < 0.001) also in the 3, 7, 14 days risk intervals than in the control intervals. This study shows that there is no increase in mortality in the short-term period after COVID-19 vaccines.

1. Introduction

Since the emergence of COVID-19, the world has taken significant measures to cope with this disease. Global efforts have been made to develop different vaccines to curb the pandemic [1] and after less than a year from the start of the pandemic, multiple vaccines were developed. Between the end of 2020 and the beginning of 2021, several of them received emergency use approval by the Food and Drug Administration and conditional marketing authorization by the European Medicines Agency. Both mRNA (BNT162b2, Pfizer-BioNTech and mRNA-1273, Moderna) and AdenoVirus vaccines (ChAdOx1-S, Oxford/Astrazeneca and Ad26 CoV2-S, Johnson & Johnson) proved to be highly effective and safe in large randomized phase 3 clinical trials [2–5].

However, rare outcomes associated with vaccines may not appear from the phase 3 trials because of the lack of sufficient power, because of the short follow up time of the studies and because the population included may differ from the population receiving the vaccine. For the same reasons, fatal events associated to vaccination may remain undisclosed in the premarket trial.

At the same time, with the large vaccination campaign there are inevitably some cases whose death is close in time to their COVID-19 vaccine, raising questions on a possible relation between death and recent vaccination. These concurrent events receive great resonance in the media, generating suspicion and concerns in the population [6,7] that likely attribute a causal link between the two events.

Thus, monitoring vaccine safety is of utmost importance to protect the intended population and to reduce fears which might otherwise reduce vaccination adherence [8] and contribute to vaccine hesitancy [6,7].

Various surveillance systems in different countries have been monitoring vaccination safety since the beginning of the vaccination campaign and by now have received numerous reports of fatal
events occurring after vaccination although they mostly did not result to be correlated to vaccination [9–12] in post-mortem investigation. Causal relationship was established only in very rare cases, such as for deaths linked to thrombotic events [13,14]. However, besides surveillance systems and a few post-mortem investigation reports [13], evidence on the risk of mortality after vaccination is scanty. Until now, few studies have been conducted to assess whether mortality is increased following COVID-19 vaccination [15–17].

We conducted a study with the main objective of assessing whether there is an increased risk of mortality in the days following the administration of COVID-19 vaccines in the population of Bologna Health Authority from December 27, 2020 to December 31, 2021. A secondary objective was to describe the characteristics of deaths and causes of death occurred after vaccination.

2. Methods

2.1. Study design setting and population

We conducted a retrospective cohort study in the vaccinated population of Bologna Health Authority (BHA). BHA is the local health care organization in charge of prevention and care of the population (about 890,000 inhabitants) living in a territory situated in Northern Italy which comprises Bologna Municipality, the main town, and other 44 municipalities. In BHA, as elsewhere in Italy, COVID-19 vaccination campaign started on December 27, 2020 and addressed first health care workers, the elderly and the frailest subjects and later was gradually extended in a schedule based primarily on age. Since December 2021 also 5–11 years old children were included as potential beneficiary of the vaccination.

BNT162b2 was the first vaccine to be authorized, but shortly afterward also mRNA-1273 and ChAdOx1-S were available. Ad26 CoV2-S was authorized mid-March. Apart from some age criteria associated with the use of ChAdOx1-S, the choice of which vaccine to administer depended mainly on the product availability and for this reason BNT162b2 was the most frequently distributed. Nevertheless, due to lighter conservation requirements mRNA-1273 was preferred by general practitioners, for home administration and by nursing homes, whereas the Public Health Department that was in charge of the distribution of vaccines to the general population used mainly BNT162b2.

We included all residents who received at least one dose of any COVID-19 vaccine authorized in Italy from December 27, 2020 to December 31, 2021. We excluded residents that moved to municipalities of other health authorities because of the uncertainty regarding their life status. The study population was identified by using the BHA COVID-19 Vaccination registry. This is a locally based register that contains information about type of vaccine, number of doses, dates and venue of administration for all subjects that received a dose of vaccine in the BHA area.

2.2. Exposure period

Participants were followed from the date of their last vaccination (day 1) for 60 days or to the date of death or to December 31, 2021 whichever occurred first. The follow-up period of each participant was divided in risk intervals and non-risk intervals (i.e. control intervals). We considered as risk interval the period within 3, 7, 14 and 30 days from day 1 and as control interval the period of the same length (3, 7, 14 and 30 days) of follow-up beyond the 30th day after the last dose of vaccination. We considered the last dose of the vaccine, assuming that the short-term mortality did not depend on the number of doses.

2.3. Outcomes and additional variables

The main outcome of the study was death from all causes. Deaths were identified by using Bologna’s Causes of Death Registry which covers all the deaths of the residents of the BHA catchment area and provides information about socio-demographic characteristics and on date, place, circumstances and initial cause of death. The cause of death derives from information recorded in the medical section of the death certificate and is classified according to the tenth revision of the ICD (International Classification of Diseases) and coded according to the WHO rules. All information is collected following national protocols. At the time of the study, the collection of all deaths that occurred during the study year, was considered complete.

We also collected additional variables to characterise the study population and/or to consider as confounders. In particular, we retrieved comorbidities of the previous two years (cardiovascular, cerebrovascular, respiratory system diseases, tumors, diabetes, hypertension, Parkinson, dementia, mental health disorders, renal failure) of the population from the local frailty database which, in turn derives from hospital discharge records, exemption and pharmaceutical archives of 2019 and 2020. This database was also used to retrieve the frailty index. The index is obtained from a multiple predictive model and is attributed to each adult resident in BHA predicting the probability of urgent hospitalization or death in the following year [18]. It ranges from 0 to 100 and is categorized into 5 classes of frailty: very low (0–5.99), low (6–29.99), medium (30–49.99), high (50–79.99), and very high (80–100). The frailty index database is available only for 18+ residents.

Information about SARS-CoV-2 infection was retrieved from a local surveillance database which contains demographic, clinical and epidemiological characteristics of all confirmed cases of SARS-CoV-2 infection in the BHA area. At the time of the study, confirmation of SARS-CoV-2 cases required a RT-PCR test using an oral and/or nasopharyngeal swab. All archives were linked with the BHA COVID-19 Vaccination registry by using the fiscal code, a unique identification code that is provided to all Italian citizens.

2.4. Ethics statement

This is a retrospective observational study where no new diagnostic tool or drug treatment was provided to any participant to conduct this study. Participant data were collected as part of standard public health surveillance activities. In accordance to Italian laws about personal data, informed consent was not required because unfeasible given the large sample size. Data were anonymized prior to the analyses after database linkage was done. Only one author conducting database linkage had access to patients identifying information.

2.5. Statistical analysis

We computed frequencies of baseline characteristics of the study population and cases. For each risk interval we calculated the rate of mortality and compared with the corresponding control interval rate. We estimated raw and adjusted IRRs (incidence rate ratio) with 95% confidence interval (CI). Adjusted estimates were obtained by applying a multivariable Poisson regression model. The model included: age class (<18, 18–40, 41–64, 65–74, 75–80, 81–84, 85–90, >90 years), day of week and period of vaccination. The study period was divided in three periods (27 December 2020–30 April 2021; 1 May–31 August 2021 and 1 September–31 December 2021) to take account of differences in mortality across the year; each subject was attributed a period according to the date of the last dose. In a secondary step we conducted a stratified analysis where a multivariable Poisson regression model...
was run also by gender, age class, type of vaccine, and excluding patients with a SARS-CoV-2 infection. The model included the same covariates as the main model, except for age which was continuous in the stratified analyses by age class. We replicated the analyses also after excluding all subjects that had a diagnosis of SARS-CoV-2 infection during the follow-up period because a protective effect of vaccination for COVID-19-related deaths was expected beyond the first week from the administration. In addition, the analyses were repeated in the adult (>18 years old) population using a model with frailty index, day of week and period of vaccination as covariates.

All analyses were performed using STATA 16.1, Texas USA software.

3. Results

Between December 27, 2020 and December 31, 2021, 717,538 subjects resident in BHA received at least one dose of one of the authorized vaccines against COVID-19. Table 1 shows the main demographic characteristics of the study populations and the type of vaccine that was administered as last dose.

During the follow-up period there have been 1152 deaths in the 30 days risk interval and 1015 in the 30 days control interval. Table 2 shows the main demographic and clinical characteristics and type of vaccine of the deaths. Deaths of risk and control intervals were mostly females and aged 85 or over. The most frequent comorbidities were tumours followed by cardiovascular diseases.

Table 1
Demographic and clinical characteristics of the study population.

| Study population | No. | % |
|------------------|-----|---|
| Total            | 717,538 | 100 |
| Sex              |       |   |
| F                | 370,813 | 51.68 |
| M                | 346,725 | 48.32 |
| Age group (years) |     |   |
| 0–17             | 44,455 | 6.20 |
| 18–40            | 186,386 | 25.98 |
| 41–64            | 280,965 | 39.16 |
| 65–74            | 90,690 | 12.64 |
| 75–84            | 75,623 | 10.54 |
| >84              | 39,419 | 5.49 |
| Citizenship      |       |   |
| Italian          | 645,600 | 89.97 |
| Non Italian      | 71,938 | 10.03 |
| Comorbidities (previous two years)* | | |
| Cardiovascular diseases | 50,157 | 7.09 |
| Tumours          | 93,942 | 13.14 |
| Diabetes         | 50,966 | 7.12 |
| Hypertension     | 63,872 | 8.93 |
| Cerebrovascular diseases | 20,417 | 2.82 |
| Parkinson        | 9,729 | 1.37 |
| Dementia         | 6,632 | 0.92 |
| Mental health disorders | 17,469 | 2.45 |
| Diseases of the respiratory system | 22,522 | 3.15 |
| Renal failure    | 9,521 | 1.34 |
| SARS-CoV-2 infection | 4,619 | 0.64 |
| Frailty class*   |       |   |
| Very low         | 472,815 | 65.90 |
| Low              | 144,401 | 19.94 |
| Medium           | 22,320 | 3.08 |
| High             | 11,244 | 1.57 |
| Very high        | 1,365 | 0.19 |
| Type of vaccine* |       |   |
| ChAdOx1-S        | 23,558 | 3.28 |
| Ad26 CoV2-S      | 5,557 | 0.77 |
| mRNA-1273        | 260,409 | 36.30 |
| BNT162b2         | 427,943 | 59.65 |

* Information not available for all.
## Table 2
Demographic, clinical characteristics and vaccine administered of deaths occurred during risk and non-risk intervals.

| Follow up period | Control interval | Risk interval |
|------------------|------------------|---------------|
|                  | 31–60 days       | 1–30 days     |
|                  | No. %            | 1–14 days     |
|                  |                  | 1–7 days      |
|                  |                  | 1–3 days      |
| Total            | 1,015 100        | 1,152 100     |
|                  |                  | 487 100       |
|                  |                  | 208 100       |
|                  |                  | 66 100        |
| Sex              |                  | 1,152 100     |
| Female           | 533 52.51        | 615 53.39     |
|                  |                  | 269 55.24     |
|                  |                  | 121 58.17     |
|                  |                  | 35 53.03      |
| Male             | 482 47.49        | 537 46.61     |
|                  |                  | 218 44.76     |
|                  |                  | 87 41.83      |
|                  |                  | 31 46.97      |
| Age group (years)|                  | 1,152 100     |
| 0–17             | 0 1.09           | 1 0.21        |
|                  |                  | 1 0.48        |
| 18–40            | 8 0.79           | 8 0.69        |
|                  |                  | 6 1.23        |
|                  |                  | 3 1.44        |
| 41–64            | 60 5.91          | 71 6.16       |
|                  |                  | 22 4.52       |
|                  |                  | 9 4.33        |
| 65–74            | 103 10.15        | 107 9.29      |
|                  |                  | 46 9.45       |
|                  |                  | 20 9.62       |
| 75–84            | 282 27.78        | 323 28.04     |
|                  |                  | 134 27.52     |
|                  |                  | 60 28.85      |
| >84              | 562 55.37        | 642 55.73     |
|                  |                  | 278 57.08     |
| Citizenship      | 1,003 98.82      | 1,142 99.13   |
| Italian          | 98 9.70          | 128 11.18     |
|                  | 52 5.58          | 59 5.53       |
|                  | 23 2.20          | 23 2.20       |
|                  | 9 0.87           | 9 0.87        |
|                  |                  | 5 0.52        |
| Bridged          | 471 46.63        | 553 48.30     |
|                  |                  | 245 50.62     |
|                  |                  | 95 46.12      |
| Divorced         | 32 3.17          | 45 3.93       |
|                  | 22 2.20          | 22 2.20       |
|                  | 4 0.48           | 4 0.48        |
|                  |                  | 2 0.21        |
| Education        | 52 5.58          | 59 5.53       |
| University       | 125 13.41        | 130 12.18     |
|                  | 60 5.91          | 60 5.91       |
|                  | 23 2.20          | 23 2.20       |
|                  | 9 0.87           | 9 0.87        |
|                  |                  | 5 0.52        |
| Primary school   | 470 50.43        | 523 49.02     |
|                  |                  | 224 49.34     |
|                  |                  | 93 48.19      |
| Comorbidities (previous two years)*| | | |
| Cardiovascular diseases | 356 35.28 | 429 37.57 | 181 37.63 | 73 35.61 | 28 43.75 |
| Tumours | 372 36.87 | 374 32.75 | 159 33.06 | 67 32.68 | 24 37.50 |
| Diabetes | 224 22.20 | 281 24.61 | 120 24.95 | 58 28.29 | 17 26.56 |
| Hypertension | 340 33.70 | 355 31.09 | 152 31.60 | 65 31.71 | 21 32.81 |
| Cerebrovascular diseases | 232 22.99 | 246 21.54 | 100 20.79 | 47 22.93 | 14 21.88 |
| Parkinson | 105 10.41 | 97 8.49 | 38 7.90 | 19 9.27 | 2 3.13 |
| Dementia | 165 16.35 | 204 17.86 | 83 17.26 | 41 20.00 | 10 15.63 |
| Mental health disorders | 39 3.87 | 36 3.15 | 10 2.08 | 4 1.95 | 0 |
| Diseases of the respiratory system | 159 15.76 | 195 17.08 | 80 16.63 | 41 20.00 | 15 23.44 |
| Renal failure | 128 12.69 | 166 14.54 | 72 14.97 | 36 17.56 | 10 15.63 |
| SARS-CoV-2 infection | 63 6.24 | 109 9.46 | 34 6.98 | 6 2.88 | 1 1.52 |
| * Information not available for all. |

## Table 3
Deaths, person-years and mortality rate × 100 during the risk and control intervals, with 95% confidence interval (CI) by follow-up period in all study population and after excluding subjects who had a confirmed SARS-CoV-2 infection after vaccination.

| n. deaths | Person-years | Rate × 100 person-years | 95 %CI |
|-----------|--------------|-------------------------|-------|
| All study population | | | |
| Control interval 31–60 days | 1,015 | 37,358 | 2.72 | 2.55   | 2.89 |
| Risk interval 1–30 days | 1,152 | 51,338 | 2.24 | 2.12   | 2.38 |
| 1–14 days | 487 | 27,220 | 1.78 | 1.63   | 1.95 |
| 1–7 days | 208 | 15,130 | 1.37 | 1.19   | 1.57 |
| 1–3 days | 66 | 5,836 | 1.13 | 0.87   | 1.44 |
| After excluding people with a SARS-CoV-2 infection after vaccination | | | | |
| Control interval 31–60 days | 952 | 37,157 | 2.56 | 2.40   | 2.73 |
| Risk interval 1–30 days | 1,043 | 51,008 | 2.04 | 1.92   | 2.17 |
| 1–14 days | 453 | 27,149 | 1.67 | 1.52   | 1.83 |
| 1–7 days | 202 | 15,029 | 1.34 | 1.17   | 1.54 |
| 1–3 days | 65 | 5,798 | 1.12 | 0.87   | 1.43 |
| Population/Subgroup | IRR   | 95 %CI  | p-value |
|---------------------|-------|---------|---------|
| Overall             | 0.63  | 0.56    | 0.71    | <0.0001 |
| Sex                 | 0.62  | 0.55    | 0.70    | <0.0001 |
| Female              | 0.67  | 0.56    | 0.79    | 0.0001  |
| Male                | 0.57  | 0.47    | 0.68    | <0.0001 |
| Age group (years)   |       |         |         |         |
| <65                 | 0.58  | 0.35    | 0.96    | 0.0357  |
| 65–74               | 0.44  | 0.29    | 0.66    | <0.0001 |
| 75–84               | 0.50  | 0.39    | 0.64    | <0.0001 |
| >84                 | 0.70  | 0.60    | 0.83    | <0.0001 |
| Vaccine type        |       |         |         |         |
| ChAdOx1-S           | 0.17  | 0.06    | 0.45    | 0.0004  |
| Ad26 CoV2-S         | 0.25  | 0.01    | 0.81    | 0.0034  |
| mRNA-1273           | 0.67  | 0.53    | 0.85    | 0.0014  |
| BNT162b2            | 0.60  | 0.51    | 0.70    | <0.0001 |
| Excluding SARS-CoV-2 infection | 0.63  | 0.55    | 0.72    | <0.0001 |
| Overall             | 0.50  | 0.42    | 0.60    | <0.0001 |
| Sex                 | 0.50  | 0.42    | 0.60    | <0.0001 |
| Female              | 0.60  | 0.47    | 0.76    | 0.0001  |
| Male                | 0.41  | 0.32    | 0.54    | <0.0001 |
| Age group (years)   |       |         |         |         |
| <65                 | 0.44  | 0.22    | 0.88    | 0.0204  |
| 65–74               | 0.41  | 0.22    | 0.74    | 0.0031  |
| 75–84               | 0.38  | 0.27    | 0.53    | <0.0001 |
| >84                 | 0.59  | 0.46    | 0.76    | <0.0001 |
| Vaccine type        |       |         |         |         |
| ChAdOx1-S           | 0.10  | 0.01    | 0.81    | 0.0347  |
| Ad26 CoV2-S         | 0.10  | 0.01    | 0.81    | 0.0347  |
| mRNA-1273           | 0.60  | 0.43    | 0.83    | 0.0033  |
| BNT162b2            | 0.46  | 0.37    | 0.58    | <0.0001 |
| Excluding SARS-CoV-2 infection | 0.54  | 0.45    | 0.65    | <0.0001 |
| Overall             | 0.41  | 0.29    | 0.56    | <0.0001 |
| Sex                 | 0.38  | 0.28    | 0.52    | <0.0001 |
| Female              | 0.44  | 0.29    | 0.68    | 0.0002  |
| Male                | 0.34  | 0.22    | 0.52    | <0.0001 |
| Age group (years)   |       |         |         |         |
| <65                 | 0.34  | 0.09    | 1.38    | 0.1310  |
| 65–74               | 0.24  | 0.08    | 0.71    | 0.0094  |
| 75–84               | 0.23  | 0.13    | 0.40    | <0.0001 |
| >84                 | 0.53  | 0.35    | 0.81    | 0.0036  |
| Vaccine type        |       |         |         |         |
| ChAdOx1-S           | 0.13  | 0.02    | 1.10    | 0.0676  |
| Ad26 CoV2-S         | 0.13  | 0.02    | 1.10    | 0.0676  |
| mRNA-1273           | 0.76  | 0.43    | 1.33    | 0.3562  |
| BNT162b2            | 0.29  | 0.19    | 0.43    | <0.0001 |
| Excluding SARS-CoV-2 infection | 0.43  | 0.31    | 0.59    | <0.0001 |

1 Adjusted for age, day of week and period of vaccination.
2 Age class 18–40 and 41–64 are grouped to increase the number of events.
residents of nursing homes and monitored deaths and other adverse events for 7 days and found lower mortality rates in vaccinated. Xu et al. [16] conducted a cohort study and analysed non-COVID related deaths during a 7 months follow up period and also reported lower rates of mortality between vaccinated and did not find major safety problems following the first or second dose of the vaccines. Lv et al. [15] reported on 55 deaths following vaccination. This was a large population-based study encompassing a period of one year where we looked at multiple timeframe after vaccination and thus including potential deaths for anaphylactic reactions that may occur within a short delay, but also for myocarditis, pericarditis and thrombotic complications that can occur two weeks later [8,13]. In addition, as we adopted a risk interval approach we did not have to compare vaccinated with unvaccinated that are nevertheless very rare and so far there is a general consensus that the benefits of vaccination far outweigh the potential risks [10,11]. Fatal events occur at any time and do occur also in temporal association with preventive measures. In this sense by studying all deaths after vaccination we did not observe any negative impact on mortality in the short-term.

5. Strengths and limitations

This was a large population-based study encompassing a period of one year where we looked at multiple timeframe after vaccination and thus including potential deaths for anaphylactic reactions that may occur within a short delay, but also for myocarditis, pericarditis and thrombotic complications that can occur two weeks later [8,13]. In addition, as we adopted a risk interval approach we did not have to compare vaccinated with unvaccinated that are expected to be very different and as such introduce bias in the results. Another strength of the study was the availability of the causes of deaths which gave us the opportunity to provide a deep insight into the main findings of the study.

This study has several limitations that should be taken into account when interpreting the results. One of the main limits of the study is that possible longer-term death associated with vaccination were not detected. In addition, as our goal was to study

### Table 5

| Place of death | Control interval | Risk interval |
|---------------|-----------------|---------------|
|               | 31–60 days      | 1–30 days     | 1–14 days    | 1–7 days    | 1–3 days    |
|               | No. | %    | No. | %    | No. | %    | No. | %    | No. | %    |
| Total         | 1,015 | 100  | 1,152 | 100  | 487 | 100  | 208 | 100  | 66  | 100  |
| Place of death | Home | 230  | 22.79 | 332  | 28.82 | 179  | 36.76 | 84  | 40.38 | 30  | 45.45 |
|               | Hospital | 589  | 58.37 | 590  | 51.22 | 197  | 40.45 | 73  | 35.10 | 20  | 30.30 |
|               | Nursing home | 154  | 15.26 | 159  | 13.80 | 80   | 16.43 | 38  | 18.27 | 12  | 18.18 |
|               | Other | 42   | 4.16  | 71   | 6.16  | 31   | 6.37  | 13  | 6.25  | 4   | 6.06  |
| Causes of deaths | Natural causes | 956  | 94.75 | 1,094 | 94.97 | 460  | 94.46 | 199 | 95.67 | 63  | 95.45 |
|               | Certain infectious and parasitic diseases | 37   | 3.67  | 29   | 2.52  | 13   | 2.67  | 7   | 3.37  | 1   | 1.52  |
|               | COVID-19 | 42   | 4.16  | 97   | 8.42  | 27   | 5.54  | 5   | 2.40  | 0   | 0     |
|               | Neoplasms | 245  | 24.28 | 199  | 17.27 | 75   | 15.40 | 29  | 13.94 | 9   | 13.64 |
| Diseases of the blood and blood-forming organs and certain disorders involving the immune mechanism | 8    | 0.79  | 6    | 0.52  | 2    | 0.41  | 1   | 0.48  | 1   | 1.52  |
| Endocrine, nutritional, and metabolic diseases | 36   | 3.57  | 53   | 4.60  | 21   | 4.31  | 13  | 6.25  | 4   | 6.06  |
| Mental and behavioural disorders | 46   | 4.56  | 54   | 4.69  | 22   | 4.52  | 9   | 4.33  | 4   | 6.06  |
| Diseases of the nervous system | 42   | 4.16  | 28   | 2.43  | 13   | 2.67  | 7   | 3.37  | 1   | 1.52  |
| Diseases of the circulatory system | 312  | 30.92 | 402  | 34.9  | 187  | 38.4  | 79  | 37.98 | 24  | 36.36 |
| Diseases of the respiratory system | 83   | 8.23  | 105  | 9.11  | 40   | 8.21  | 20  | 9.62  | 13  | 19.70 |
| Diseases of the digestive system | 35   | 3.47  | 45   | 3.91  | 21   | 4.31  | 9   | 4.33  | 1   | 1.52  |
| Diseases of the skin and subcutaneous tissue | 4    | 0.40  | 6    | 0.52  | 2    | 0.41  | 0   | 0     | 0   | 0     |
| Diseases of the musculoskeletal system and connective tissue | 3    | 0.30  | 6    | 0.52  | 2    | 0.41  | 1   | 0.96  | 0   | 0     |
| Diseases of the genitourinary system | 45   | 4.46  | 39   | 3.39  | 21   | 4.31  | 7   | 3.37  | 2   | 3.03  |
| Congenital malformations, deformations and chromosomal abnormalities | 1    | 0.10  | 0    | 0     | 0    | 0     | 0   | 0     | 0   | 0     |
| Symptoms, signs and abnormal clinical and laboratory findings, not elsewhere classified | 17   | 1.68  | 25   | 2.17  | 14   | 2.87  | 11  | 5.29  | 3   | 4.55  |
| External causes of morbidity and mortality | 59   | 5.85  | 58   | 5.03  | 27   | 5.54  | 9   | 4.33  | 3   | 4.55  |
short-term mortality associated with vaccination, some events that occurred 30 days after vaccination (the control interval) might have a relationship with the vaccine. Other study design with longer follow-up should be conducted to explore long-term adverse events and long-term mortality of COVID-19 vaccines.

Another limit of the study is the small size of some subgroups which is not sufficient to detect significant differences. By observing the main clinical characteristics of the participants, we did not find important differences when comparing deaths during the risk vs the control interval.

By comprising >700,000 vaccinated subjects of all ages and analysing all fatal events occurred after the administration of COVID-19 vaccines, we did not find any negative impact in the short-term mortality during the first year of the campaign, a finding that may contribute to reducing hesitancy towards these vaccines.

All authors attest they meet the ICJME criteria for authorship.

Data availability
Data will be made available on reasonable request.

Declaration of Competing Interest
The authors declare that they have no known competing financial interests or personal relationships that could have appeared to influence the work reported in this paper.

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Appendix A. Supplementary material
Supplementary data to this article can be found online at https://doi.org/10.1016/j.vaccine.2022.08.039.

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